INSTRUCTIONS WITH PARTS LIST

WESTON®

1240 DIGITAL MULTIMETER

INSTRUCTIONS WITH PARTS LIST

FOR

WESTON®

MODEL 1240

DIGITAL MULTIMETER

NOTE

This book applies to
instruments having
Serial No. 4000 and above

U. S. Patent 3,051,939

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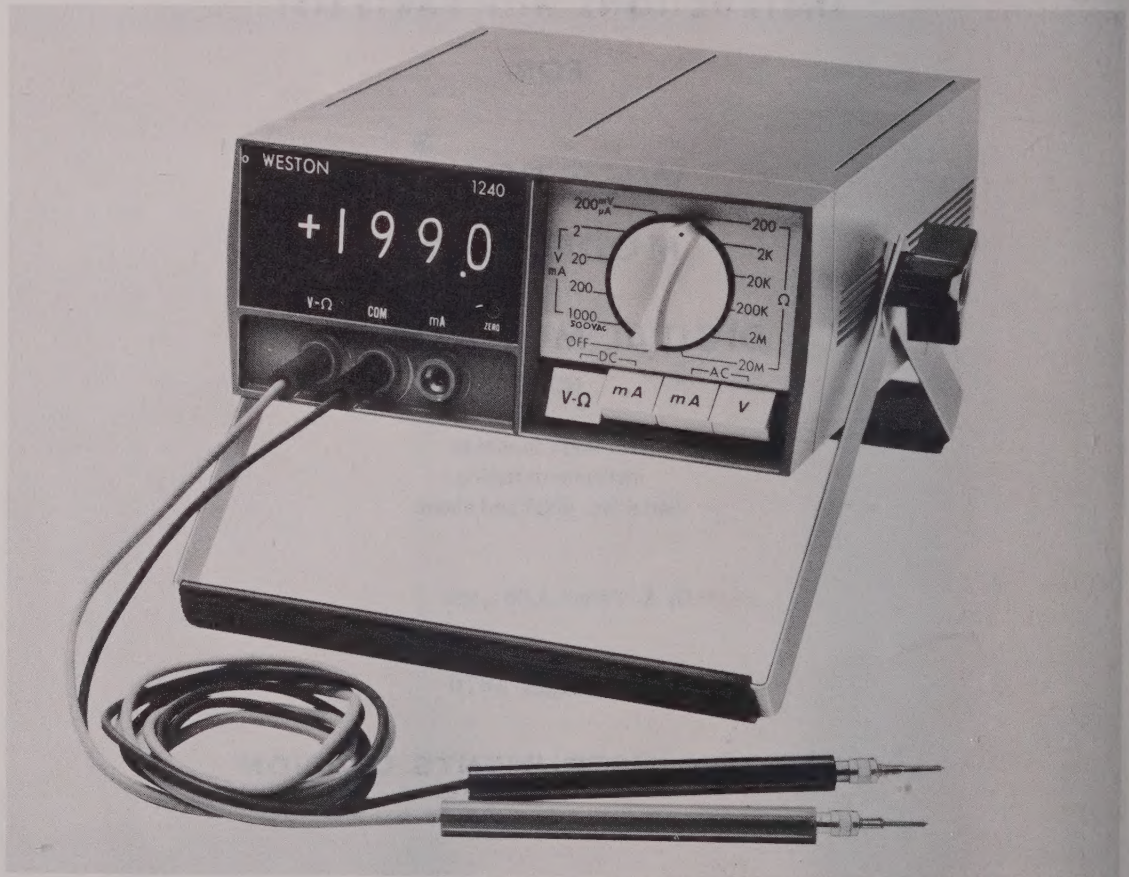

Figure 1. Model 1240 Digital Multimeter with Handle/Stand and Test Probes

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GENERAL INFORMATION

DESCRIPTION.

The Weston Model 1240 is a compact digital multimeter designed for maximum operator convenience and utility. Five voltage and five current ranges, both AC and DC, as well as six resistance ranges are self-contained in a high-impact resistant plastic case.

The basic measuring circuit is a high impedance bipolar analog to digital converter which employs dual-slope integration to achieve excellent accuracy and long term stability. The basic measurement ranges are 200 millivolts and 2 volts DC at an accuracy of ±0.1% of reading ±0.05% of full scale. All other ranges and functions are converted to one of these basic ranges for measurement as a DC voltage.

A custom-designed thin-film attenuator extends DC voltage measurements to 1000 volts with a voltage coefficient less than 100 parts per million at 1000 volts. Overrange capability permits useful readings of DC voltage of at least 50% beyond the inherent 2000 bits.

AC voltage is converted to DC by an average - sensing, RMS - calibrated, operational rectifier which extends the AC voltage range from 200 millivolts full scale to an allowable maximum of 500 volts.

Current is measured by the voltage drop it establishes across a precision shunt network. If DC - it is measured directly; if AC - it is first converted by the operational rectifier. Currents from 0.1 microampere to 2 amperes can be measured with a voltage drop of only 200 millivolts full scale across the shunt.

Resistance is measured by passing a scaled constant current through the unknown and measuring the DC voltage across it. Resistance ranges from 200 ohms to 20 megohms are provided with a measuring current of no more than 1 milliampere (at the 200 ohm range).

The mechanical design of Model 1240 has stressed operator convenience and confidence in its straight-forward control/connector layout and full overload protection. Easy portability is evident, too, in its small size, fully recessed controls, and connectors, and its battery pack compatibility for field use.

Carrying handles serve a dual purpose as a tilt-stand for any viewing angle during table top operation. The instrument may be panel mounted without any additional parts.

Optional accessories include a battery pack capable of over 6 hours of continuous field operation and overnight recharge, and a leather carrying case.

Power requirements are 115 VAC or 230 VAC at frequencies of 50/60/400 Hz.

SPECIFICATIONS

Size:	3" high x 7" wide x 7.9" deep
Weight:	Approx. 4 pounds (1.9Kg)
Display:	Maximum Count: 1999 Overrange Indication: Automatic beyond 1999 Polarity Indication: Automatic "+" or "-" Reading Rate: 5 per second, non-blink (200 millisec integration time). Numeric Display by side-viewing neon glow tubes with integral decimal points

SPECIFICATIONS (Continued)

Power
Requirement: ... 115 VAC or 230 VAC
Tolerance: +15%, -10%
Line Frequency: 50Hz to 400Hz
Power Drain: 6.0 watts, nominal

Accessories: .... Combination carrying handle tilt stand - standard on all units
Battery Pack - optional
Leather carrying case - optional

Additional
Features: ..... All fuses accessible from outside of unit. May be operated 500 volts above power line ground

Operating
Temperature: ... 10°C to 40°C
Reference: 25°C ±1°C

DC VOLTS

Range	Zin	Rated Accuracy	Overload Protection
200mV	⏦ 100MΩ	±0.1% rdg. ±1 digit	350V
2V	⏦1000MΩ	±0.1% rdg. ±1 digit	350V
20V	10MΩ	±0.1% rdg. ±1 digit	1000V
200V	10MΩ	±0.1% rdg. ±1 digit	1000V
1000V	10MΩ	±0.1% rdg. ±1 digit	1000V

Overrange
Capability: ..... 20% minimum (subject to overload protection limits)

Resolution: ..... 100 microvolts

Full Scale
Step Response: .. 2 seconds to rated accuracy

Input Bias
Current: ..... 10 na maximum at reference conditions

Temperature
Influence: ..... ±0.005% Rdg/°C ±0.1 digit /°C

Normal Mode
Rejection: ..... 35 db minimum at 60 Hz

Common Mode
Rejection: ..... 80 db minimum with 1K unbalance at 60 Hz. Can be operated on batteries for extended CMRR

RESISTANCE

Range	Test Current	Rated Accuracy	Overload Protection
200 Ω	1 MA	±0.5% rdg. ±1 digit	250V RMS*
2 K	100 μa	±0.25% rdg. ±1 digit	250V RMS*
20 K	10 μa	±0.25% rdg. ±1 digit	250V RMS
200 K	10 μa	±0.25% rdg. ±1 digit	250V RMS
2 M	1 μa	±1% rdg. ±1 digit	250V RMS
20 M	100 na	±1% rdg. ±1 digit	250V RMS

Resolution: .... 0.1 ohm

Full Scale
Step Response: .. Two seconds on ohm and K ohms ranges; 10 seconds at 10 megohms

Temperature
Influence: ..... ±0.05% rdg/°C ±0.1 digit/°C

Overrange
Capability: ..... 20% minimum

*by fuse and clamp diodes

AC VOLTS (Mean Sensing, RMS Calibrated)

Range	Zin	Overload Protection
200 mV	1 megohm	250V RMS
2 V	at 150 pf	250V
20 V		500V
200 V		500V
500 V		500V

SPECIFICATIONS (Continued)

Accuracy: .....±0.5% rdg ±1 digit, 40Hz to 10KHz
±1.0% rdg ±1 digit, 10KHz to 20KHz

Resolution: .....100 microvolts

Full Scale
Step Response: ..5 seconds to rated accuracy

Temperature
Influence: .....±0.05% rdg/°C ±0.1 digit/°C
40Hz to 10KHz
±0.1% rdg/°C ±0.2 digits/°C
10KHz to 20KHz

DC AMPS

Ranges	Voltage Drop (nominal)	Rated Accuracy
200 μA	0.2 volt.	±0.25% Rdg ±1 digit
2 MA	0.2 volt.	±0.2% Rdg ±1 digit
20 MA	0.2 volt.	±0.2% Rdg ±1 digit
200 MA	0.2 volt.	±0.3% Rdg ±1 digit
2 A	0.2 volt.	±0.5% Rdg ±1 digit

Resolution: .....100 nanoamperes

Overload
Protection: .....3 amps, any range, by fuse and clamp diodes

AC AMPS (40 Hz to 10KHz)

Ranges	Voltage Drop (nominal)	Rated Accuracy
200 μA	0.2 volt.	±0.75% Rdg ±1 digit
2 MA	0.2 volt.	±0.7% Rdg ±1 digit
20 MA	0.2 volt.	±0.7% Rdg ±1 digit
200 MA	0.2 volt.	±0.8% Rdg ±1 digit
2 Amps	0.2 volt.	± 1% Rdg ±1 digit

Resolution: .....100 nanoamperes

Overload
Protection: .....3 amps, any range, by fuse and clamp diodes

INSTALLATION

GENERAL

Inspect the instrument for possible damage in shipment. If damage is noted, notify the carrier and supplier before using the instrument.

CARRYING HANDLES

Remove the carrying handles and knobs from the accessory container. Mount handles to the case as shown in Figure 2. The knobs differ at their threaded ends and may be used on either side of the case. When oriented for carrying both handles should be rotated to the front of the case, at which point their detents will lock and may be secured by tightening the knobs.

TILT-STAND OPERATION

For bench or table top use, the handles should be locked in the open position shown in Figure 2. Two stable orientations of the handles are possible, each providing a different height off the table. In one position the inner handle is forward; in the second, it is to the rear.

It is important that the detents on the handles be engaged when in the tilt-stand position in order to provide maximum stability.

PANEL MOUNTING

The Model 1240 has been provided with an option for mounting on a 1/8 inch panel. Special mounting screws have been provided in the instrument and the panel cut-out dimensions are given in Figure 3.

In mounting the instrument on a prepared panel the circuit board inside the case must be repositioned forward by 1/8 inch. To perform

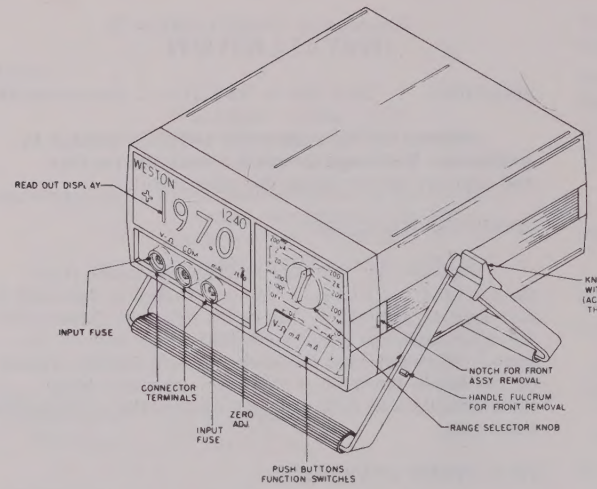

Figure 2. Handle/Stand Assembly

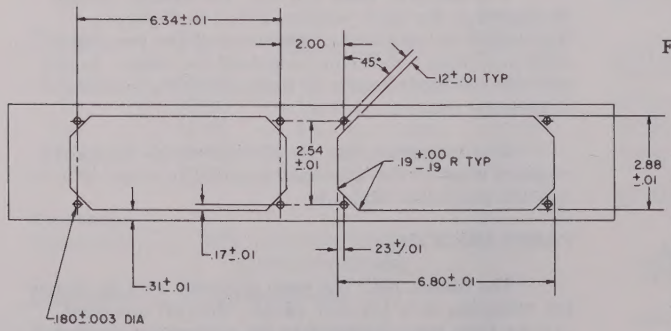

Figure 3. Panel Cut-out Dimensions

this modification without damage to the instrument the following instructions should be carefully followed. (See Figures 4 and 5)

CAUTION

Before proceeding, all push buttons must be in the "up" position and must remain up until modifications and mounting are completed. The buttons may be restored to the "up" position by depressing two buttons simultaneously.

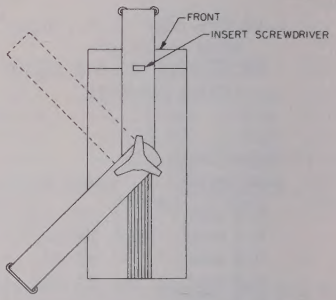

Figure 4. Removal of Front Assembly Using Handle/Stand as Fulcrum

a. Stand case on back end with inner handle locked in the front position as shown in Figure 4.

b. The front may now be removed. Starting on one side, insert a screwdriver blade, about 1/8 inch extended through the rectangular hole provided in the inner handle, and into the notch provided in the front assembly. Using the handle as a fulcrum, gently pry the front upwards. It will snap into a new position, 1/8 inch forward. Repeat on the other side. Now reset the screwdriver blade 1/16 inch lower on the front so as to engage the edge of the front assembly, and pry up the front one more notch on each side. The front will now come free.

c. Before pulling off the front, swing the handle clear of the front and reset in the table top position.

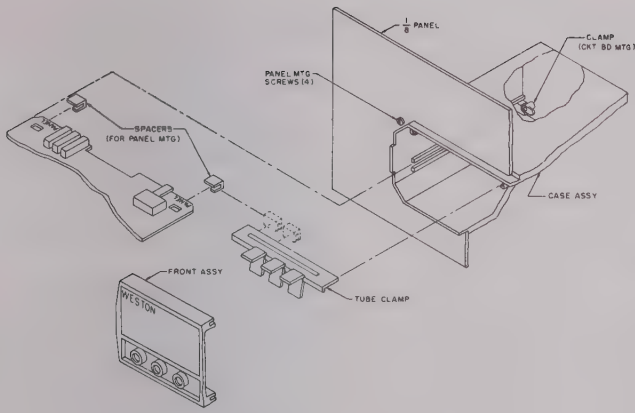

Figure 5. Panel Mounting (optional)

d. Facing the instrument's front, gently pull the front forward, maintaining care that the switch contacts behind push buttons are not damaged. The switch shaft may come out with the front. Lay the front down on the table.

e. Remove the shaft from the front and replace it in the rotary switch assembly.

f. The leads may now be removed from the front and the front put aside temporarily. Note the interconnections so as to reconnect correctly. (See Figure 24).

g. The handles may now be removed.

h. To remove the circuit board, rotate the two screws at the rear of the case 1/2 turn counterclockwise. This will rotate two clamps freeing the board from the case. (See Figure 5) Remove the edge connector guard at this time.

i. Grasp circuit board from the front of the case and remove. This can be assisted by pushing on the rear of the circuit board at the edge of the accessory connector.

j. The board must be advanced 1/8 inch forward in the case to allow for panel mounting clearance. One eighth inch spacers have been provided on the tube clamp. Remove the tube clamp and break off the L shaped spacers at its rear edge. (See Figure 5) Trim spacer edge with razor blade.

k. Slip the spacers onto the rear of the circuit board behind the rectangular cutouts in the space marked PANEL. The spacers should be oriented with the cutout side down. Secure them in place with a small amount of cement such as pliobond. When properly positioned none of the word "Panel" will be visible.

l. The circuit board mounting clamps must now be advanced by 1/8 inch to engage the new position of the cutout. Rotate the clamp screws at the rear counterclockwise about 6 turns until both clamps can be rotated past the stops built into the case.

m. Insert the circuit board into the case making sure that the clamps can slide into the cutouts on the circuit board in this new position.

n. Slide out the circuit board one-third of its length and reinsert the tube clamp in back of the display tubes and into the slides provided within the case.

o. Slide the circuit board all the way back into the case and secure by rotating the screw clamps. Replace edge connector guard.

p. The case may now be mounted into the prepared panel by means of the screws and inserts provided at the front of the case.

q. The leads may now be connected to the front assembly. Be cautious that the switch contacts are not damaged in the process.

r. The front panel may now be reinstalled on the case. Observe that all buttons are up and that the notch in the range knob lines up with the spline on the switch shaft.

BATTERY PACK OPTION

Instructions for mounting the battery pack accessory are provided with the battery pack. Interconnection will be made through the accessory connector at the rear of the case. When operated without a battery pack the accessory connector must be protected to prevent accidental contact with lethal voltages. A guard has been provided for this purpose and must be kept on the instrument.

POWER REQUIREMENTS

The Weston Model 1240 has been designed to operate on 115 VAC or 230 VAC, 50Hz to 400Hz. A rear panel switch permits operation in either mode. Be sure that the switch is in the proper position for the local power lines before applying power. If 115 VAC is applied in the 230 volt position, only a faint display will occur. If 230 VAC is applied in the 115 VAC position, a rear panel fuse will blow out. The line voltage ratings of this instrument will permit it to extend to 15% above or 10% below nominal line voltage.

The Model 1240 is equipped with a three conductor power cable that grounds the instrument when plugged into a suitable outlet. In addition, the fused side of the power connector will be automatically connected to the high side of the line, on all outlets wired in accordance with U. S. Underwriters Laboratory Standards. To preserve this feature when operating with a two contact outlet, use an adapter and connect the pigtail on the adapter to a suitable ground. Also be sure that the adapter is oriented so as to apply the high side of the line to the fused power input terminal. (See Figure 8, rear panel description for further details).

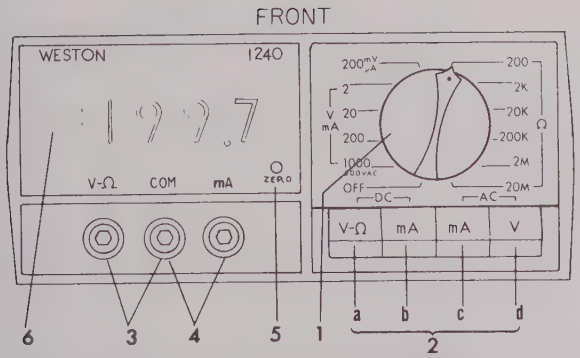

Figure 6. Front Panel Description

OPERATION

1. Range Switch
   a. Applies AC power to instrument. ON is any position but OFF.
   b. Permits range selection for AC or DC Voltage or Current when switched to V-mA, in conjunction with push button function switch.
   c. Permits when switched to ohms position, in conjunction with V-Ω push button switch.
2. Function Push Button Switches
   a. Permits in conjunction with range switch the measurement of DC volts or ohms.
   b. Permits in conjunction with range switch the measurement of DC current.
   c. Permits in conjunction with range switch the measurement of AC current.
   d. Permits in conjunction with range switch the measurement of AC volts.
3. Input V-Ω jack (left) and COM jack (center) are inputs for AC and DC volts and ohms.
4. Input mA jack (right) and COM jack (center) are inputs for AC and DC current.
5. Zero adjustment.
6. Display
   a. Three cold cathode numeral tubes with internal decimal points. Decimal point is automatically determined by the range switch.
   b. An overrange digit to carry thousands digits information. This will either indicate "1" or not at all.
   c. "+" and "-" polarity indicators to automatically indicate polarity of input for DC volts and milliamperes, it reads "+" for resistance measurements and remains inactive for AC volts and milliamperes.
   d. An overrange lamp indicates an input beyond 1999. It will flick periodically up to 100% overrange and will remain on steadily if the A/D converter is overranged to saturation.

All circuits are protected for overloads either through a resistor-diode network, or through fuses which are replaceable from outside of the case. See figure below. Two fuses are located behind the input jacks on the case front, the third fuse is located behind the AC line input receptacle in the rear of the case. All fuses may be reached by removing their receptacles with wrench as follows:

1. Input V-Ω jack supports a 3/16 amp. 8AG fuse for protecting instrument input, the constant current source used in resistance measurement. The fuse is removed with a wrench built into the knob handle.

2. Input mA jack supports a 3 amp. 8AG fuse for protecting the current shunts. The fuse is removed with a wrench built into the knob handle.

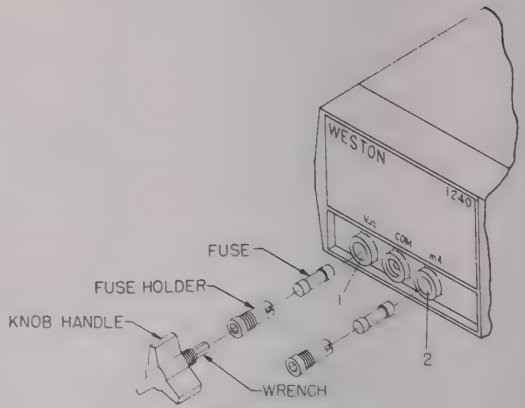

Figure 7. Input Fuse Replacement

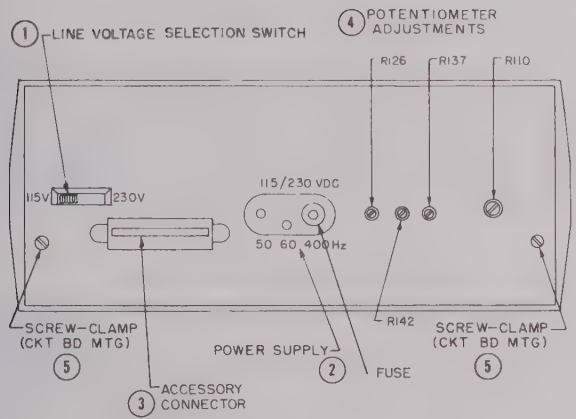

Figure 8. Rear Panel Description

1. Line voltage selector is a two position slide switch. Left position is for 115 volt power line operation. Right position is for 230 volt power line operation.

2. AC Power line connector is a three pin recessed male connector. The right hand pin supports a 1/4 amp. 8AG fuse. It is removed with the aid of the small wrench designed into the tip of one of the tilt stand knobs.

3. The accessory connector is provided to accommodate the accessory battery pack. When used without the battery pack, it should remain protected by the insulated cap provided with the instrument.

4. Four adjustments(ohms calibration, +V, -V, 20MΩ) are provided for periodic standardization. See Maintenance Section.

5. Screw-clamps used for securing circuit board.

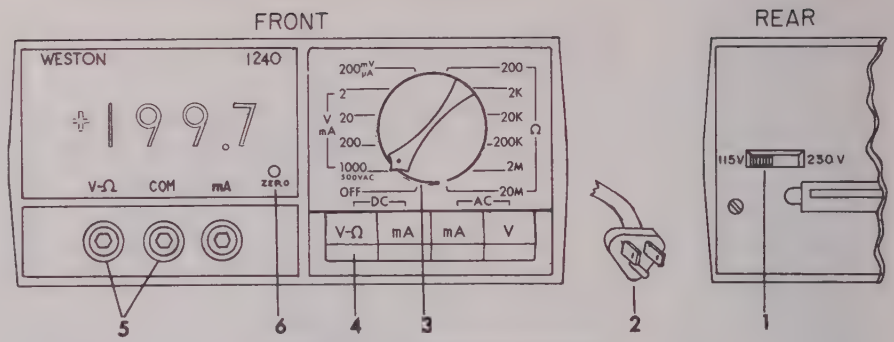

Figure 9. DC Voltage Measurement

1. Set line voltage selector switch on rear panel to proper line voltage position.
2. Plug in power cord to instrument and AC power outlet.
3. Set range switch to 1000 or the desired lower range if known.
4. Depress the function push button DC (V-Ω) to the down position.
5. Connect test leads to the jacks marked V-Ω and COM. Allow 15 minutes warm-up time for stabilization to insure best accuracy.
6. Short test leads and set range switch to 200mV. The display should read zero with polarity indicator flickering between + and -. If not rotate the zero control to achieve this.

NOTE

If the input leads are left open circuited on the 200mV or 2 volt ranges, the display reading will slowly increase due to the presence of a small current appearing across the high input impedance of the converter. A similar effect occurs on any range if all the push buttons are up. On the 20, 200, and 1000 volt ranges the reading will remain at zero.

7. Set instrument to 1000V range, apply input and observe reading. If readout exceeds 1000V remove input immediately as overload condition exists. Otherwise, reduce range switch until proper range is reached. Table below indicates proper readout limits for each range.

Range	Proper Readout Limits
200mV	00.0 - 199.9
2V	.199 - 1.999
20V	1.99 - 19.99
200V	19.9 - 199.9
1000V	199 - 1000

NOTE

Unit may be used to 50% overrange on all ranges but 1000V. For example, 220 volts would be displayed a 20.0 plus flashing overrange indicator on the 20 volt range.

CAUTION

Do not float the meter more than 500V above ground or damage to the instrument may result.

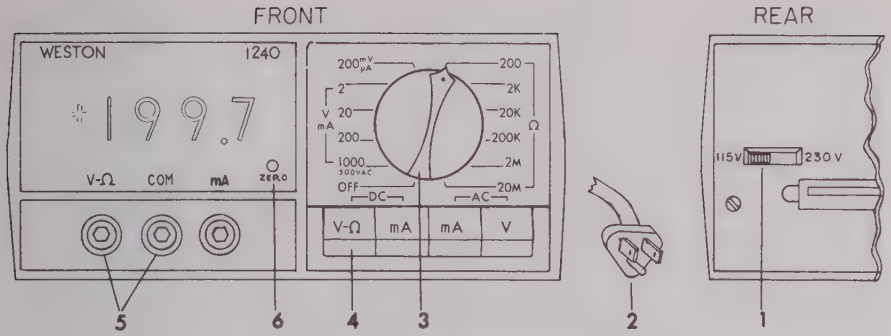

Figure 10. Ohms Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position.
2. Plug in power cord to instrument and the AC power outlet.
3. Set range switch to the desired range.
4. Depress the function push button DC (V-Ω) to the down position.
5. Connect test leads to the input jacks marked V-Ω and COM. Allow 15 minutes to warm-up for stabilization to insure best accuracy.
6. Short test leads. The display should read zero with polarity indicator flickering between "+" and "-". If not rotate the zero control to achieve this.

NOTE

When using the 200 ohm range, the reading with shorted input test leads may differ from the other ohmic ranges. A small residue of less than one ohm (10 digits) may be indicated due to lead resistance. The user has the option of either subtracting this residue from his measurement of the unknown or nulling the lead resistance out by adjustment of the zero control. If the latter option is taken the meter must be re-zeroed when returning to other ohmic ranges or modes of operation.

7. Connect test leads to unknown resistance and observe reading. Increase or decrease range until proper range is reached. Table below indicates proper readout limits for each range.

Range	Proper Readout Limits
200Ω	00.0 - 199.9
2K	.199 - 1.999
20K	1.99 - 19.99
200K	19.9 - 199.9
2M	.199 - 1.999
20M	1.99 - 19.99

NOTE: Unit may be used to 50% overrange. For example, 270KΩ would be displayed as 70.0 plus flashing over-range indicator on the 200KΩ range.

CAUTION

The resistance measurement circuitry is protected against the application of voltage. The four highest ranges are inherently protected to 250 volts DC or AC by the power dissipation of internal components. The two lowest ranges are clamp diode protected at between 1 and 2 volts and fuse protected beyond this to 250 volts, the rating of the fuse.

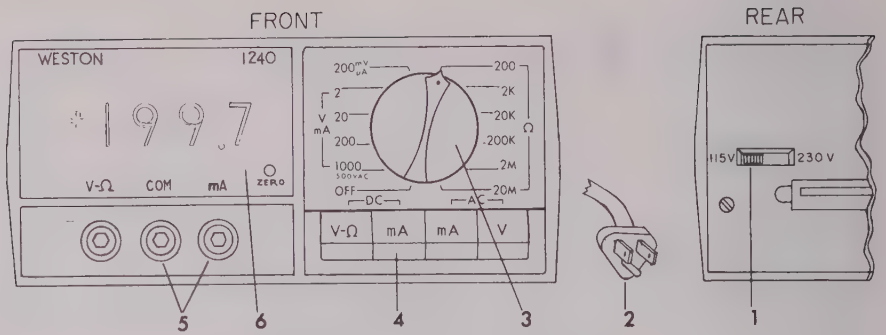

Figure 11. DC Current Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position.
2. Plug in power cord to instrument and the AC power outlet.
3. Set power/range switch to 2 amperes or the desired lower range if known.
4. Depress the function push button DC-mA to the down position.
5. Connect the unknown DC current into input jacks mA and COM.
6. Observe reading : decrease range switch until the proper range is reached.

Range	Proper Readout Limits
200 μA DC	0 - 199.9
2 mA DC	.199 - 1.999
20 mA DC	1.99 - 19.99
200 mA DC	19.9 - 199.9
1000 mA DC	.199 - 1.999*

*While the dial is calibrated 1000 max. the full scale range on all current ranges is 1999 digits.

NOTE

Unit may be used to 50% overrange on all ranges but the 2 ampere range. For example, 270 ma would be displayed as 70.0 plus flashing overrange indicator on the 200 ma range.

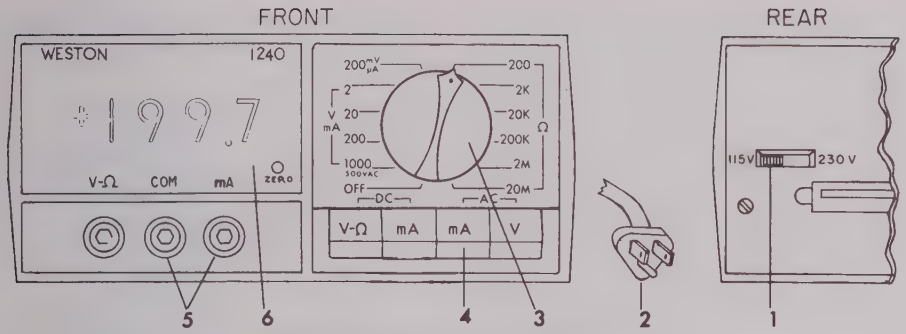

Figure 12. AC Current Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position.

2. Plug in power cord to instrument and the AC power outlet.

3. Set range switch to 1000mA or to the desired lower range if known.

4. Depress the function pushbutton AC-mA to the down position.

5. Connect the unknown AC current into input jacks mA and COM.

6. Observe reading: decrease range switch until proper range is reached.

Range	Proper Readout Limits
200 μA AC	0 - 199.9
2 mA AC	.199 - 1.999
20 mA AC	1.99 - 19.99
200 mA AC	19.9 - 199.9
1000 mA AC	.199 - 1.999*

* While the dial is calibrated 1000 max., the full scale range on all current ranges is 1999 digits.

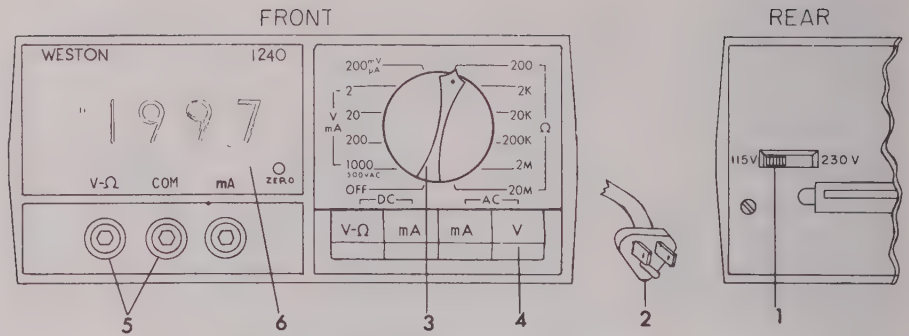

Figure 13. AC Voltage Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position.

2. Plug in power cord to instrument and the AC power outlet.

3. Set power/range switch to 1000 or the desired lower range if known.

CAUTION

500 Volts is the maximum AC voltage allowable in the 1000V position.

4. Depress the function push button AC-V to the down position.

5. Observe readings. Decrease range switch until proper range is reached.

6. Observe readings. Decrease range switch until proper range is reached.

Range	Proper Readout Limits
200 mV AC	0 - 199.9
2 V AC	.199 - 1.999
20 V AC	1.99 - 19.99
200 V AC	19.9 - 199.9
500 V AC	199 - 500.0

NOTE: When measuring AC voltage or currents, distorted sine waves can be a source of error. This instrument will indicate within rated accuracy only on pure sine waves. Typical 3rd harmonic distortion levels can introduce errors as much as 1/3 of the percentage of 3rd harmonic distortion present.

THEORY OF OPERATION

INTRODUCTION

This section presents the design and operating principles of the Weston 1240 Digital Multimeter. The theory of operation is presented at the functional level in the section immediately below and in greater detail on the pages following. Complete schematic diagrams are included for reference in the Maintenance Section.

Model 1240 incorporates all circuitry needed to make measurements of DC voltage and current, AC voltage and current, and Resistance.

The basic measuring circuit is a high impedance bipolar analog to digital converter operating on the dual-slope principle. It has a measurement range of either 200 mV or 2 volts DC, depending on the range switch setting. All inputs other than DC volts are converted to DC volts for measurement by this circuit.

Resistance is measured by passing a scaled constant current through the unknown and measuring the DC voltage across it.

Alternating voltages are converted to DC by an average sensing, RMS calibrated converter assembly. Full scale output voltage for all ranges is 2 volts DC.

Current is measured by the voltage drop it establishes across a ring shunt network. If DC, it is measured directly. If AC, it is applied to the AC converter first. Full scale shunt voltage is 200 millivolts for all ranges.

The DC voltmeter and the several conversion circuits are interconnected by a complex of function switches and rotary range switches which make possible decimal point switching, input ranging, gain changes in the A/D converter, shared usage of the precision attenuator and a switchable protection function. Rather than present the complete system diagram in the text, with all of its switching complexity, we have elected to present the functional modes, one sub-circuit at a time, indicating the required signal interfaces. Interconnection information is presented in the master schematic diagrams in the maintenance section and the interested user will be better equipped to follow it after first digesting the operating theory of the functional parts.

We have started with the A/D converter, that circuit being basic to all other modes. Then the front-end analog circuitry including attenuator and switching which complete the DC voltmeter circuit. Resistance, current, and AC converter, and power supply follow in that order.

The following sections will present the theory of operation of the DC voltmeter and the several conversion circuits.

DETAILED CIRCUIT DESCRIPTION

DC VOLTMETER CIRCUIT

Common to all measuring functions is a high input-impedance, dual slope, bipolar A/D converter. The input voltage may be either 200 mV DC or 2 Volts DC depending on range setting. All the voltages are scaled to one of these ranges by suitable attenuators, shunts, or converters. The display has a maximum reading of 1999 suitable accompanied by decimal points, polarity signs and an overrange display.

The circuit operation will be explained with the aid of Waveforms Figure 14 and the Block Diagram Figure 15.

DUAL SLOPE A/D CONVERSION

Dual slope is an integrating method of A/D conversion which, in common with all integrating techniques, reduces the effect of power-frequency interference on the input or appearing as power supply ripple. Integrating time in the Model 1240 is 200 MS, providing excellent rejection of 50 Hz, 60 Hz and 400 Hz and any other components whose periods are integral sub-multiples of 200 MS.

The dual slope feature has an added, unique advantage among integrating DVM's. Older systems converted amplitude into a time interval, then to be digitized by counting the number of clock pulses in that interval. Conversion accuracy was directly dependent on clock accuracy. Dual slope, by contrast, converts amplitude into a ratio of two time intervals, both proportional to clock period and hence independent of clock accuracy.

Figure14 "F" shows the integrator waveform responsible for this conversion. Integrating cycle time T is constant at 200 milliseconds, corresponding to 8,000 pulses from the 40 KHz clock oscillator. The cycle, is divided into two intervals; ramp up, t1 and ramp down, t2.

During t_1 the integrator charges to a voltage $E_{in}\, t_1/RC$. During t_2, the capacitor discharges an equal amount under the influence of E_{in} and I_{REF} such that $\frac{E_{in}\, t_1}{RC} = \left[\frac{I_{REF}}{} - \frac{E_{in}}{R}\right] \frac{t_2}{C}$

Since $t_1 + t_2 = T$, then $t_2 = \frac{E_{in}}{I_{REF}} \frac{T}{R}$

Since the interval T is determined by 8,000 clock pulses and thus lasts 8,000/fc seconds, and the number of clock pulses N in t_2 is t_2 fc, we find that $N = 8000 \frac{E_{in}}{I_{Ref} R}$ a quantity independent of fc.

Since the interval t_2 starts at a count of 8,000 (or zero) the count at the end of t_2 is equal to "N". A storage command at that time transfers the count "N" into display storage.

The conversion process repeats with a new conversion every 200 milliseconds. If the new count is the same as the previous one, the number in storage will not change, and no display flicker results.

The key events in each cycle are the count "8,000" which initiates t_2 by introducing a reference current, and the crossing of zero by the integrator, which terminates t_2 and commands a readout into storage.

DC VOLTMETER - LOGIC SECTION

The analog to digital converter and the 2,000 bit display it generates is under the control of an 8,000 bit timing sequence, (See Figure 15), driven by a 40 KHz clock oscillator. The 40 KHz clock signal drives an 8,000 bit counter chain consisting of 3 decade counters U201, U202, U203 and three binary dividers U213B, U214A, and U214B. Counters U201, U202, and U203 accumulate counts up to 999 and drive three corresponding storage registers. The three binaries register the 1000 count and provide overrange sensing and control functions. Waveforms at the three flip-flops are shown at "A", "B", and "C" of figure 14.

Synchronization

When "B" and "C" simultaneously go to zero, the state "8,000", is detected by coincidence detector U211C. This is a reference condition which occurs only once in 8,000 pulses and is used to start interval t_2. In detecting 8,000, waveform "D" goes from 0 to 1, a transition which sets a control register called Ramp Down Latch (U211A, B.) The Ramp Down Latch occupies a central position in the operation of the converter. When set, producing a negative pulse

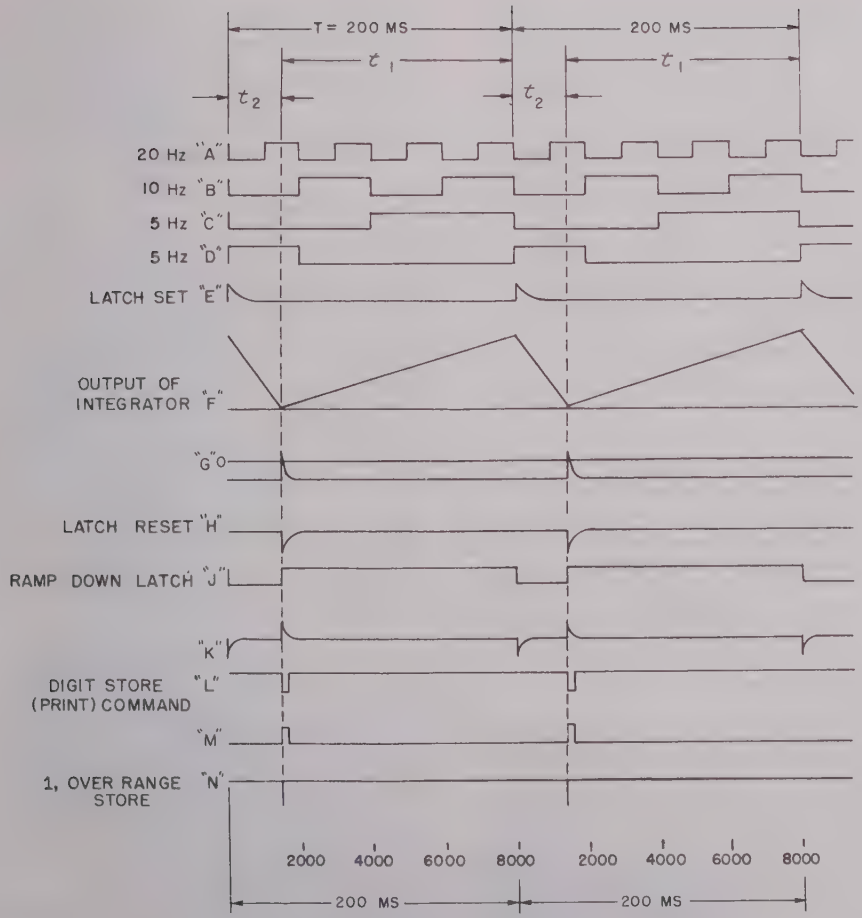

Figure 14. Waveforms

waveform "J", it permits a reference current to be injected into the integrator, starting interval t_2.

Polarity Display

Simultaneously, the negative transition of "J" triggers Polarity Storage F-F (U215A), causing it to take a state determined by the polarity of the input signal at that time. For the present example, a positive input causes a positive ramp. Therefore, at the onset of t_2, "F" is at its greatest positive value. "G" is negative since U103 inverts. U103 and U210F provide steering inputs to Polarity Store U215A, causing the positive polarity indicator to be set. Polarity indication will remain fixed, unblinking, as long as the input polarity remains the same.

Reference Current Control

During t_2, the "0" state of the Ramp Down Latch enables "I_{REF} control", permitting one of the reference current generators to inject a 400 μa current into the summing junction. The choice of reference current polarity is made by the control logic under control of the steering inputs provided by U103 and U210F. Since input signal polarity is positive, a positive current is injected into the negative input of U101 forcing the integrator back to zero.

Zero Crossing

Interval t_2 ends when the integrator reaches zero. In so doing, the output of zero-comparator U103 undergoes an abrupt positive transition. The resulting waveform generated at "G", is shaped into a negative trigger pulse at "H". (If the input voltage had been negative, a negative transition at "G" would be similarly shaped after inversion by Inverter U210F. Therefore, any zero-crossing is converted into a negative trigger pulse). The zero-crossing trigger pulse at "H" is inverted and applied to reset the Ramp Down Latch. (It will be noted that the positive transition of waveform "D" is coupled over to the reset inverter. This provides a 6 μsec inhibit period which prevents a logical race condition at zero input level.) When the Ramp Down Latch is reset, the resulting positive transition at "J" accomplishes several things, as noted below.

Readout Command

First, it is shaped and inverted into a 1 μsec negative pulse, waveform "L". This commands the storage registers U204, U205, U206 to accept new count information from the decade counters. The count transferred at this time will be the number "N" developed during t_2. The storage registers will remain receptive to changing count data so long as the command pulse is low. Time is thus made available for ripple through of carries which may have started just prior to reset. Also, during the storage command pulse, the clock oscillator is momentarily clamped, preventing any new pulses from entering the counter. At the termination of storage pulse "L", the storage registers are locked up at their new condition and the display tubes they drive remain fixed in display.

The trailing edge of the storage pulse activates two more functions. It commands transfer of the state of the "thousands" counter, U213B, into storage register U213A and triggers overrange Flip-Flop U215B. This register is set to zero (lamp off) at the start of t_2. It will toggle to "1" (lamp on) when triggered, only if both steering inputs are low. This condition, "B" low, will occur after the count of between 2,000 and 4,000, the only stable overrange condition permissible.

For further details of the logic circuitry, refer to Figure 27. Schematic Logic Section, in the Maintenance Section.

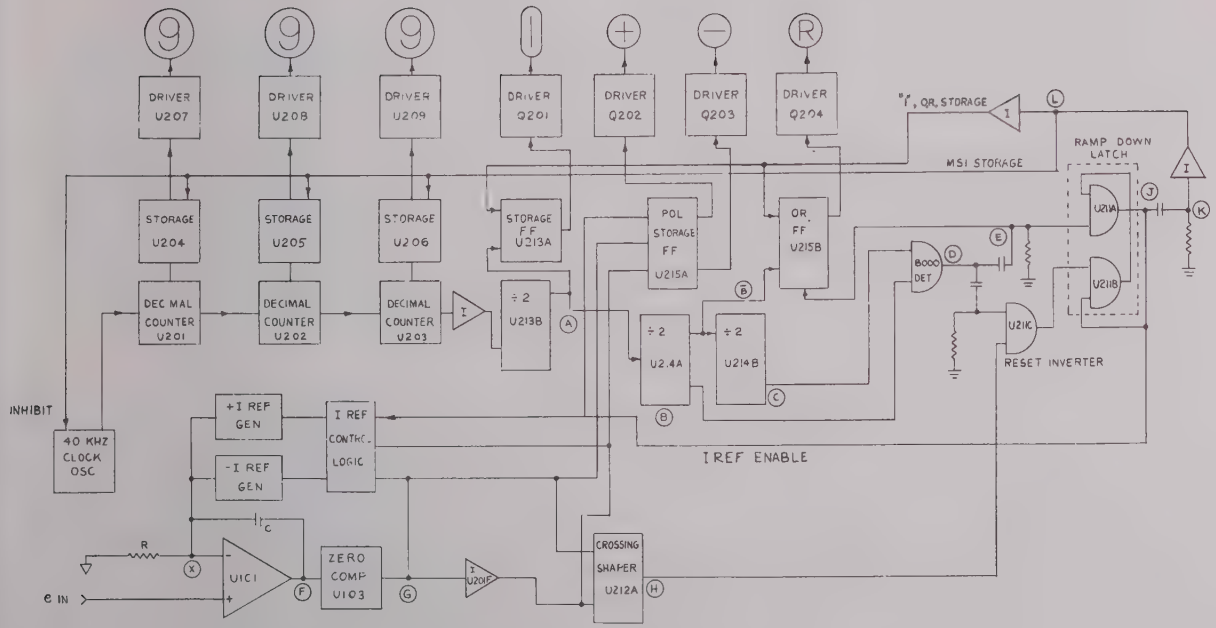

Figure 15. Block Diagram

DC VOLTMETER-ANALOG SECTION

The previous section described the operation of the A/D converter, with emphasis on the logic section. This section will describe the integrator section, with detailed consideration of biasing, gain switching, and reference current generator circuits. For greater detail and specific component values, refer to Figure 26, Schematic Analog Section, in the Maintenance portion of this manual.

The Non-Inverting Integrator

The basic integrator circuit, shown below, consists of an operational amplifier connected in the non-inverting mode for high-input impedance, and the logic-controlled current source necessary for controlling ramp action, as described in the previous section. The assumption is made that R = 2K,

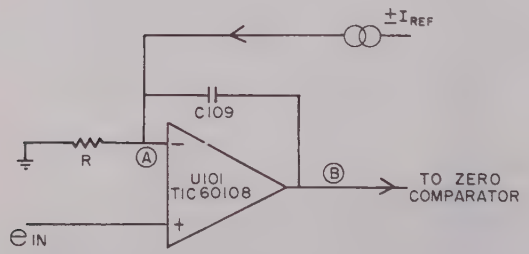

Figure 16. Integrator Circuit

C = 1.75 mf and I_{REF} = ±400 μa. If, for example an input voltage of +100 mV is applied, the feedback amplifier causes point "A" to rise to 100 mV forcing 50 μa through "R". In the absence of a reference current, the 50 μA is provided by the constant-rate charging of C109, and point "B" will rise linearly to support this charge rate.

When, at the count of 8,000, a reference current of 400 μa is switched into point "A", the reference source will supply the 50 μa and the remaining 350 μa will discharge C109. Point "B" will then fall back towards zero at a rate seven times as great as its rise and will take a 1,000 clock bits to do this,* giving rise to a display of 100.0. Other input voltages will give rise to corresponding fall times and displays. For example, a 200 millivolt input would cause 100 μa to flow through "R". A three-to-one time ratio would occur and the display count would be 2,000. In order to scale this converter up to 2 volts, we change "R" to 20K. Now, the 100 μa full scale current requires an input voltage of 2 volts and I_{REF} need not be changed.

Offset Adjustment

Offset voltages in U101, if not compensated, would produce a continuous ramp at B, even with zero input, and the display would stabilize at some small, non-zero reading. To compensate for offset voltage, the ground end of the integrating resistor R is returned to an adjustable voltage, low-impedance, source as shown in figure 18.

R114 and its associated resistors provide a 10 ohm source, adjustable to ±8 mV to accommodate an 8 mV possible offset voltage in the amplifier. The offset adjustment need not be changed when changing ranges.

* Since one complete period 8,000 bits the rise will consume 7,000 and the fall 1,000.

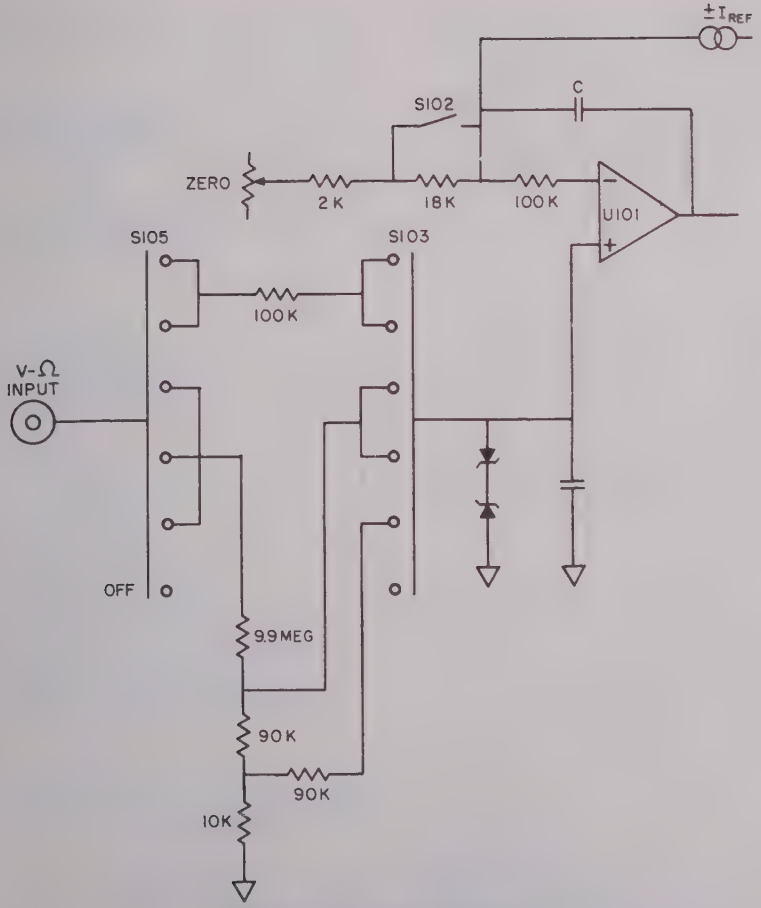

Figure 17. Input Attenuation

Input Attenuation (Figure 17)

On the 200 mV and 2 V ranges, E_{in} is applied directly to U101 through a 100 K buffering resistor which both guarantees a minimum balancing source resistance of 100 K and serves to absorb overloads. The 20 V, 200 V, and 1 KV ranges make use of a 10 megohm thin film attenuator designed to provide amplifier input voltages of 200 mV, or 2 V. Since source resistance is constant for all

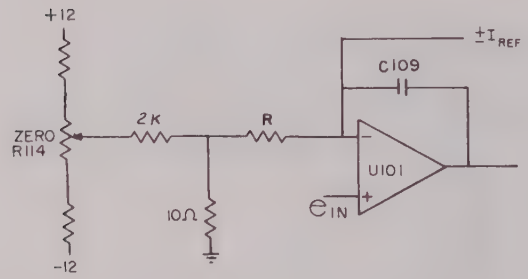

Figure 18. Offset Adjustment

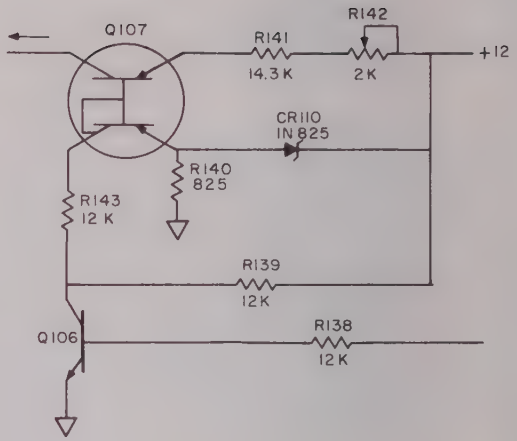

Figure 19. Reference Current Circuit.

ranges, it can be balanced by a permanent 100K resistor at the inverting input.

The switching of range voltage back and forth between 200 mV and 2 V requires that the resistor in the feedback loop change from 2 K to 20 K. S102 is arranged to close on the 200 mV and 20 volt ranges.

Zener diodes and input capacitor are provided for input overload protection and supplementary interference rejection, respectively.

Reference Current Circuits

The reference current generators consist of a common-base transistor constant current source, and is illustrated in Figure 19 for the case of the positive reference.

Q107 is the constant current source controlled, since h_{FE} is high, by the current in its emitter. This current is determined by R141, R142, and the reference voltage of CR110. Since the voltage drops of the two base-emitter junctions of Q107 tend to track, the emitter current will equal almost precisely the zener voltage divided by (R141 +R142). R142 is made variable to compensate for resistor and zener diode tolerance variations, and is adjusted during calibration to provide a reference current (nominally 400 μa) sufficient to display 2000 digits for a full scale input voltage.

R140 is provided to insure that CR110 operates at the 7.5 mA operating point recommended for best temperature stability.

R138, R139, R143, and Q106 provide a means for turning off the reference current by turning off Q106 and biasing off Q107.

OHMS CONVERSION

Resistance is converted to a DC voltage by means of a current source according to the table below. The currents are scaled to produce full-scale voltages of +200 mV on the lower ohms ranges and 2 volts on the three highest ranges.

Range	I source	(Rs) R scale	E(Rx)FS
200 Ω	1 ma	1 K	200 mV
2 K	100 μa	10 K	200 mV
20 K	10 μa	100 K	200 mV
200 K	10 μa	100 K	2 V
2 M	1 μa	1 M	2 V
20 M	100 na	10 M	2 V

It will be noted that a voltage of 1 volt is maintained across the scaling resistor on all ranges. This is accomplished by a boot-strapping technique as shown in Figure 20.

The voltage developed across Rx, called E(Rx), is applied to the voltmeter input. Because the operational amplifier forces the same voltage to occur at both inputs, we also feed E(Rx) over to the second amplifier U102. A 1 ma current source applied to the inverting input of U102 acts through the associated 1 K resistor to develop an additional 1 volt which adds to E(Rx) producing E(Rx) +1 V. Since the scaling resistor Rs is connected between the output of U102 and the OHMS input terminal, the voltage across it will be maintained at 1 volt.

The current through Rs is then determined only by Rs as shown in the table above and will be constant independent of Rx. Assuming that negligible current is drawn by amplifier U101 (a practical assumption for most ranges) then the constant current will all flow through Rx creating the voltage to be measured.

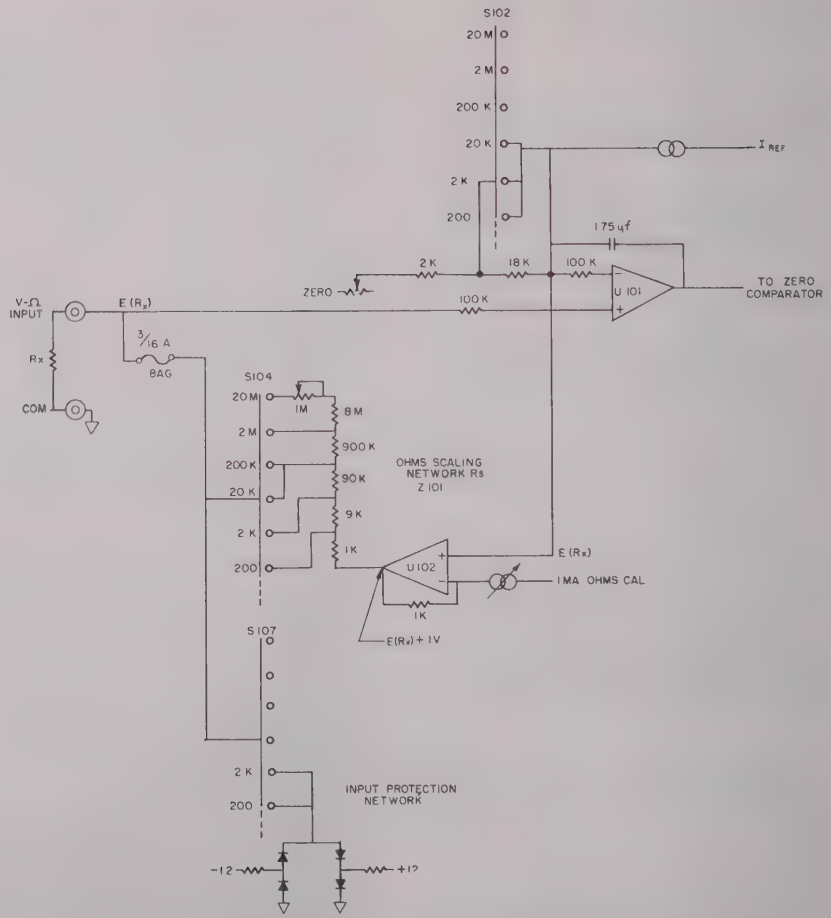

Figure 20. Ohms Conversion Circuit

Special design considerations which exist at the 200 ohm range and the megohm ranges are treated as follows:

(a) 200 ohms - The nominal value of Rs is 1 K. However, the input protection fuse (included to protect Rs from overload) has about 3.5 ohms cold resistance which could introduce a scale error of 0.35%. The resistor labeled 1 K is actually 996.5 ohms to compensate for the 3.5 ohms. Variations in fuse resistance is not enough to force the instrument out of specification.

(b) 20 Megohms - The 20 meg range makes use of a 10 megohm scaling resistor to produce a 100 na current source. Higher currents would force E(Rx) to unacceptable values. The 100 na is not all available to Rx since up to 10 na of bias current can be drawn by the input of U101. To compensate for this drain, the 10 meg scaling resistor must be reduced and a range of 9 meg to 10 meg can be provided by adjustment of a 1 meg variable resistor.

(c) 2 Megohms - This range, operating on a 1 μa constant current source is susceptible to bias current effects to the extent of 1% of reading. This small error did not warrant a compensation control, but the scaling resistor was decreased from 1 megohm to 996 K to allow for an average value of bias current, the spread of which is sufficiently small to permit the 2 meg range to remain within specification.

Input protection is provided by the fuse and a clamp network. Only the two smallest resistive elements of Z101 are protected since the higher resistance segments have adequate self-protection.

DC CURRENT CONVERSION

DC current is converted to a DC voltage by the network shown in Figure 21. Five 0.1% wirewound resistors are arranged in series, with taps, selectable by the range switch, at 0.1, 1, 10, 100, and 1000 ohms. The remaining circuitry is provided for overload protection only.

Current applied between the mA and COM jacks flows through the selected portion of the shunt network, developing a voltage between the selected tap and circuit ground. Since the total shunt resistance increases in decade steps as current range decreases, the full scale shunt voltage remains fixed at 200 millivolts for all ranges.

Accuracy is maintained on the highest current range by using a four-terminal Kelvin connection for the 0.1 ohm resistor. Thus, currents of up to 2 amperes are kept out of the potential circuit and cannot create added voltage drops in the intervening leads to appear as measurement errors.

The shunts are protected from damage due to excessive current by a combination of diode-clamps and fuse. The clamp circuit consists of two pairs of diodes, one for each polarity of overload. The 3A30 is a general purpose power diode permanently biased into conduction so as to back bias the low leakage A15FX4. Since the full scale voltage is 200 millivolts, the upper diode will normally be back-biased between 400 and 800 millivolts, a level sufficient to prevent excessive leakage, even for the 200 μa range. If a constant current sufficient to generate more than 1.2 volts is applied, the diodes will conduct and divert any larger currents away from the shunt resistors.

If the current should rise beyond 3 amperes, due to an excessive current source, or due to application of full line voltage, the fast response 3 amp fuse will blow and both shunts and diodes will be protected. The diodes have sufficiently high surge rating to withstand the momentary current pulse generated until the fuse disconnects.

All that has been said of DC current conversion applies equally to AC current conversion, except the

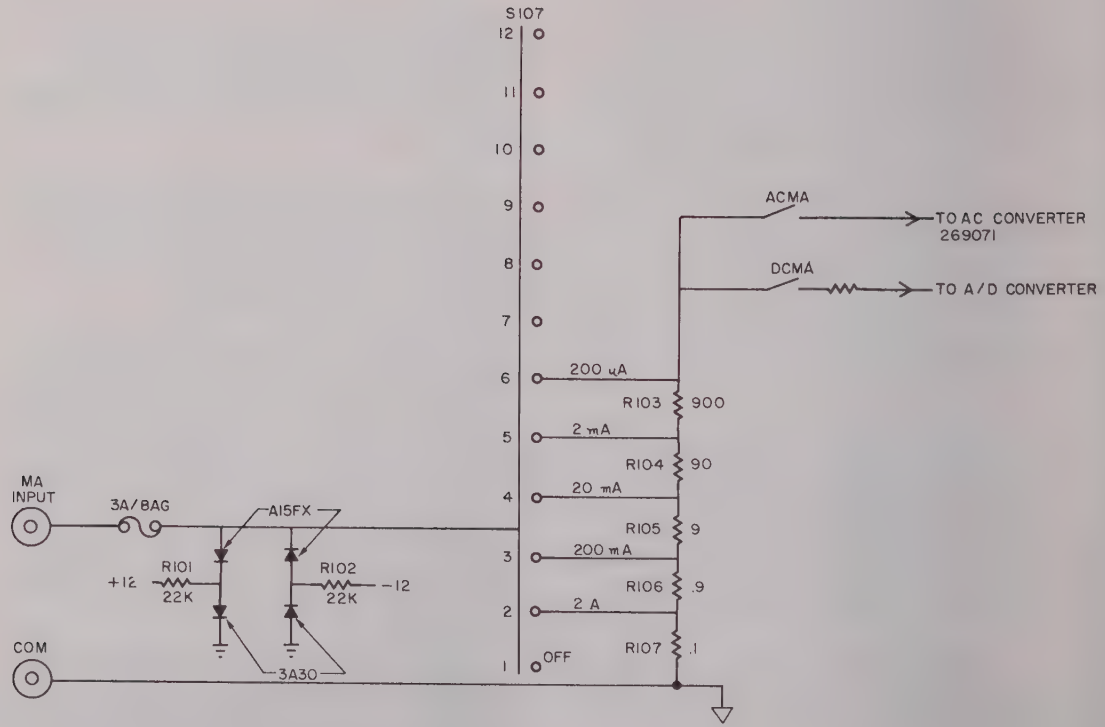

Figure 21. Current Converter Circuit

routing of shunt voltage. In the case of AC currents, a voltage waveform of 200 mV RMS full scale is generated in the potential circuit. This waveform is converted to a DC voltage of 2 volts full scale by the AC Converter assembly. Interface between the shunt network and the operational rectifier in the AC Converter assembly is discussed more fully in the Section below.

AC CONVERSION

The measurement of alternating voltages is accomplished by an average sensing, RMS calibrated, operational rectifier. It is essentially a half-wave rectifier, supported by:

An operational amplifier....	to effectively sharpen the diode switching characteristic
Gain control.....	to introduce the 1.11 conversion factor between average and RMS
Output filtering.....	to filter out the ripple component before applying the resultant DC voltage to the A/D Converter
A frequency compensated... input attenuator, and a high input impedance follower circuit	to buffer the operational rectifier from source impedance variations introduced by the attenuator

These circuit elements are shown in simplified form in Figure 22. Tracing signal flow from input terminal through to the A/D converter the following circuit functions are encountered:

1. Input Switch: the first switch, ACV, is one of three switch contacts on the ACV push button switch. It functions to protect the input coupling capacitor on the AC board from high DC voltages which might be applied in the DCV mode.

2. The input capacitor - serves to block DC Components which might be present along with the AC Component to be measured.

3. The input attenuator - is a 1 megohm resistor string with taps at 1/100 and 1/1000. Frequency compensation is provided by three capacitors, two of them adjustable. The capacitors are chosen large enough to swamp out the effects of switch capacity and strays.

Signal levels of 200 mV or 2 V maximum by-pass the attenuator and are applied directly to the buffering circuit which drives the operational rectifier. Signals larger than two volts are attenuated to the 2 volt FS or 200 mV FS level.

4. Following the attenuator is a clamp network formed by two low leakage, low capacitance diodes. The buffering resistor, R405, and the diodes protect the FET buffer stage in case of inadvertent application of destructive voltages to the 2 V or 200 mV range.

5. A FET/bipolar follower circuit provides high input impedance and low output impedance at approximately unity gain.

6. Following the buffer circuit is the input network of the operational rectifier. Voltages of 200 mV or 2 volts, either direct input or derived from the attenuator are converted into input currents of 20 microamperes RMS. The

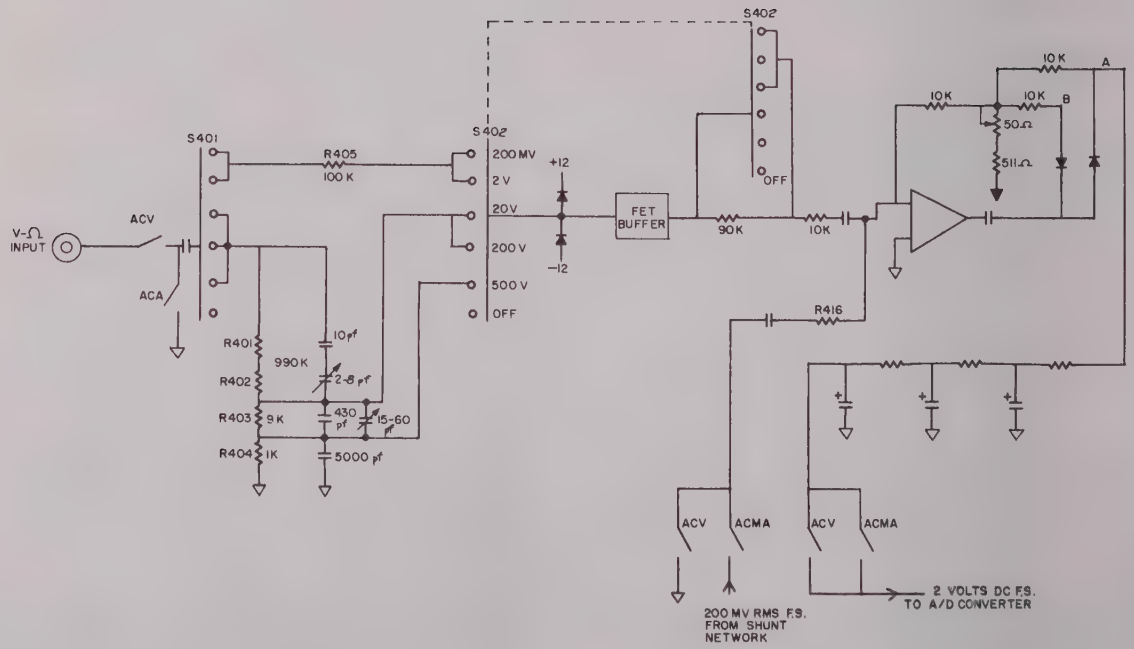

Figure 22. A.C. Converter Circuit

input network switches in value from 10 K to 100 K respectively to maintain full scale input current at the 20 microampere level.

7. The operational rectifier provides sharp half-wave rectification and gain. Positive half cycles of the input waveform produce a negative half-wave rectified sine wave at point B. Negative half cycles produce a positive half-wave rectified sine wave at A. Subsequent multistage RC filtering of the waveform at A leaves only the DC component. The feedback ratio is adjustable to provide a peak output voltage of 6.28 volts for a 20 microampere input signal.

8. The half wave rectified sine wave at A is filtered by a three pole low pass filter, designed to minimize ripple content without introducing excessive response-time delays. The source impedance seen by the A/D converter, looking back into the low pass filter is 100 K, so as to maintain the source impedance balance required for good zero - stability, by the A/D converter.

The steps described above carry an AC voltage from input through to DC Voltage output. Another mode of operation is accommodated by the AC Converter assembly when the AC mA button is depressed. This is the case when measuring sinusoidal currents. An AC voltage of 200 mV RMS, maximum is generated by the shunt network used for current conversion. It is applied directly to the operational rectifier through a supplementary input, bypassing the input attenuator and the FET buffer. The input resistor which interfaces the shunt network with the operational rectifier is scaled to provide 20 microamperes input current at full scale, and takes into account the high, 1000 ohm source resistance posed by the shunt network.

To prevent interaction between the AC mA circuitry and the AC V circuitry, and suppress pickup of spurious signals, shorting contacts are provided at the AC volts input of the converter board and at the shunt input terminal. Thus, the AC V input is shorted to ground when in AC mA operation and vice versa.

POWER SUPPLY

The power supply circuit for Model 1240 provides a regulated ±12 volt source for the analog and reference circuitry, and a regulated 3.6 volt source for the digital circuits. In addition, a half-wave rectifier supplies a 225 volt peak source for the numeral display tubes and neon indicators.

Pre-Regulation of the current through the 12 volt zener diode is provided to accommodate a +15% to -10% line voltage variations without requiring the excessive power dissipation which resistive regulation would impose.

Two nominal line voltage levels of 115 V and 230 Volts have been accommodated by a switch changing the primary winding connections from parallel to series aiding.

A supplementary winding has been added to the transformer to provide energy for recharging a battery in the battery pack accessory, and to serve as part of the DC to AC Converter, provided with the battery pack. By making the converter winding part of the power transformer, converted battery power automatically replaces AC line power. A schematic diagram of the power supply will be found in Figure28, in the maintenance section.

MAINTENANCE

In the course of normal operation, the Model 1240 should require no maintenance other than the occasional replacement of indicator lamps or overload protection fuses. Faulty operation may often be traced to improper settings of controls. A brief list of potential symptoms and suggested remedies is in order.

1. Power Fuse blown out - check setting of 115 V/230 V switch on rear panel. If line voltage is 230 volts, the switch should be set accordingly.

2. Half-bright or ill-defined display - rear panel switch may be set to 230 volts on a 115 V AC line.

3. Dim or partially defined digits on one or more indicator tubes - normal wear condition of numeral glow tube. Numeral tubes may be replaced after removing the window, a flexible panel which will be removed and reinserted by curving it about a horizontal axis.

4. Dim neon bulb indicators (+, -, "1", "R")- this is a normal wear condition. Neon indicator may be easily unsoldered for replacement since they are assembled with eyelets. See Installation Panel Mounting for instructions on Front Removal.

5. Runaway display - this is indicative of an open in the input circuit to the A/D Converter. Either all push-buttons are up, or the situation is a normal result of operating on the two lowest AC or DC voltage ranges. If the test leads are not terminated in a return path the display will escalate uncontrollably. Check the circuit being measured for continuity.

6. Ohms circuit does not respond - check the 3/16 amp fuse behind the V-Ω jack. If this has blown, the current source will be cut off from the unknown resistor and no reading will be possible.

TEST EQUIPMENT REQUIRED

The following table lists the test equipment required for checking performance or calibration. It is important to use instruments of adequate accuracy and with a recalibration period sufficient to assure confidence in the results.

TEST EQUIPMENT

EQUIPMENT	PURPOSE	REQUIRED SPECIFICATION
DC Voltage Standard	DC Voltage Calibration	Accuracy: ±0.01% Range: 100mV to 1000V
DC Current Standard	DC Current Calibration	Accuracy: ±0.02% Range: microampere to 2 amperes
AC Voltage Standard	AC Voltage Calibration	Accuracy: ±0.1% Range: 100mV to 500 volts Frequency: 40Hz to 20KHz
AC Current Standard	AC Current Calibration	Accuracy: ±0.1% Range: microampere to 2 amperes Frequency: 40Hz to 10KHz
Resistance Standard	Resistance Calibration	Accuracy: ±0.1% Range: 0.1 ohm to 20 megohm

PERFORMANCE CHECK

To verify the specifications of the Model 1240, the following performance check is recommended.

Where reference standards are required, it is important to use units of adequate accuracy and with a recalibration period sufficient to assure confidence in the results.

DC VOLTAGE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt operation as required.
2. Connect power cord to instrument and AC power source.
3. Set range switch to 200 millivolt position.
4. Depress function push button DC (V-Ω) to the down position.
5. Insert test leads in jacks V-Ω and COM. Allow a warm-up time of approximately 15 minutes to assure best results.
6. With test leads shorted, adjust the zero control on the front until the display reads 00.0 and the polarity lamps flicker back and forth.
7. Set output of DC voltage standard to zero. Connect V-Ω and COM leads on the Model 1240 to (+) and (-) output terminals respectively on voltage standard.
8. Referring to the following table, set voltage standard to output levels tabulated. Set power range switch to its appropriate setting on Model 1240. Check to insure that readout falls within the limits specified, if not refer to the appropriate calibration procedure.

DC VOLTAGE ACCURACY AT REFERENCE CONDITIONS

Voltage Input	Range Switch Setting	Readout Limits Min.	Max.
Input Shorted		± 00.0	± 00.1
± 01.0		± 00.9	± 01.1
± 10.0	200mV	± 09.9	± 10.1
±100.0		± 99.8	±100.2
±200.0		±199.7	R± 00.3
Input Shorted		± .000	± .001
+1.000	2V	± .998	±1.002
+2.000		±1.997	R± .003
+10.00	20V	± 9.98	±10.02
+20.00		±19.97	R± 0.03
+100.0	200V	± 99.8	±100.2
+200.0		±199.7	R± 00.3
+ 500	1000V	± 499	± 501
+1000		± 998	+1002

RESISTANCE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt AC line operation as required.
2. Connect power cord to instrument and AC power source.
3. Depress function push button DC (V-Ω) to the down position.
4. Set range switch to the 2KΩ range.
5. Insert test leads in jacks V-Ω and COM. Allow a warm-up time of approximately 15 minutes to achieve best results before testing.
6. With test leads shorted adjust the zero control on the front until the display reads .000 and the plus and minus lamps flicker back and forth.

NOTE

When checking the 200Ω range for accuracy, it will be necessary to rezero the meter to compensate for test lead resistance.

7. Connect meter to resistance standard.
8. Referring to the following table, set resistance standard to values listed. Set Model 1240 range switch to the proper range. Check to insure readout is within the limits given, if not refer to calibration procedure.

RESISTANCE ACCURACY AT REFERENCE CONDITIONS

Resistance Standard	Range Switch Setting	Readout Limits Min.	Max.
.000	2KΩ	.000	.001
1.000KΩ		.996	1.004
2.000KΩ		1.994	R .066
10.00KΩ	20KΩ	9.96	10.04
20.00KΩ		19.94	R 0.06
100.0KΩ	200KΩ	99.6	100.4
200.0KΩ		199.4	R 0.6
1.000MΩ	2MΩ	.989	1.001
2.000MΩ		1.979	R .021
10.00MΩ	20MΩ	9.89	10.11
20.00MΩ		19.79	R 0.21
00.0	200Ω	000	001
100.0		99.4	100.6
200.0		198.9	R 01.1

DC CURRENT ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt line operation, as required.

2. Connect power cord to instrument and AC power source.

3. Set range switch to the 1000mA setting.

4. Depress function push button DC (mA).

5. Insert test leads in mA and COM jacks. Allow a warm-up time of approximately 15 minutes to achieve best results before testing.

6. Set output of DC current standard to zero. Connect mA and COM leads on the Model 1240 to (+) and (-) output terminals respectively on current standard.

7. Referring to following table set current standard to values listed. Set Model 1240 range switch to the proper range. Check to insure readout is within the limits given.

DC CURRENT ACCURACY AT REFERENCE CONDITIONS

DC Current Input	Range Switch Setting	Readout Limits Min.	Max.
00.0		± 00.0	± 00.1
+100.0μa	200μa	+ 99.7	+100.3
+200.0μa		+199.4	R+ 00.6
+1.000mA	2 mA	+ .997	+1.003
+2.000mA		+1.995	R+ .005
+10.00mA	20 mA	+ 9.97	+10.03
+20.00mA		+1.995	R+ 0.05
+100.0mA	200 mA	+ 99.6	+100.4
+200.0mA		+199.3	R+ 00.7
+1000mA	1000mA	+ 994	+1006
+2000mA		+1989	R+ 011

AC VOLTAGE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt AC line operation as required.

2. Connect power cord to instrument and AC power source.

3. Set range switch to 1000V position.

4. Depress function push button AC (V) to the down position.

5. Insert test leads in V-Ω and COM jacks. Allow a warm-up time of 15 minutes to obtain best results.

6. Set AC voltage standard to zero. Connect V-Ω and COM leads on the Model 1240 to the output terminals on AC voltage standard.

7. Referring to the following table set voltage standard to output levels tabulated. To fully check AC voltage performance tests at the tabulated levels should be made at frequencies of 40Hz, 60Hz, 400Hz, 10KHz and 20KHz. Set the range switch on the Model 1240 to its appropriate setting. Check to insure that the readout falls within the limits specified.

AC VOLTAGE ACCURACY AT REFERENCE CONDITIONS

AC Voltage Input	Range Switch Setting	Readout Limits 40Hz to 10KHz		Readout Limits 10KHz to 20KHz	
		Min.	Max.	Min.	Max.
00.0 MV	200MV	00.0	00.1	00.0	00.1
100.0 MV		99.4	100.6	98.9	101.1
200.0 MV		198.9	R 01.1	197.9	R 02.1
.200 V	2 V	.198	.202	.196	.204
1.000 V		.994	1.006	.989	1.011
2.000 V		1.989	R .011	1.979	R .021
2.00 V	20 V	1.98	2.02	1.96	2.04
10.00 V		9.94	10.06	9.89	10.11
20.00 V		19.89	R 0.11	19.79	R 0.21
20.0 V	200 V	19.8	2.02	19.6	20.4
100.0 V		99.4	100.6	98.9	101.1
200.0 V		198.9	R 01.1	197.9	R 02.1
200 V	500 V	198	202	196	204
500 V		496	504	492	508

AC CURRENT ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument, for 115 or 230 volt AC line operation as required.
2. Connect power cord to instrument and AC power source.
3. Set range switch to 100mA position.
4. Depress function push button AC (mA) to the down position.
5. Insert test leads in mA and COM jacks. Allow a warm-up time of 15 minutes to obtain best results.
6. Set AC current standard to zero. Connect mA and COM leads on the Model 1240 to the output terminals of the current standard.
7. Referring to the following table set current standard to output levels tabulated. (To fully check AC current, performance tests at the tabulated levels should be made at frequencies of 40Hz, 60Hz, 400Hz and 10KHz). Set range switch on the Model 1240 to its appropriate setting. Check to insure that the readout falls within the limits specified.

AC CURRENT ACCURACY AT REFERENCE CONDITIONS

AC Current Input	Range Switch Setting	Readout Limits 40Hz to 10KHz	
		Min.	Max.
00.0μa	200μa	00.0	00.1
100.0μa		99.2	100.8
200.0μa		198.4	R 01.6
1.000mA	2mA	.992	1.008
2.000mA		1.985	R .015
10.00mA	20mA	9.92	10.08
20.00mA		19.85	R 0.15
100.0mA	200mA	99.1	100.9
200.0mA		198.3	R 01.7
1000mA	2000mA	989	1011
2000mA		1979	R 021

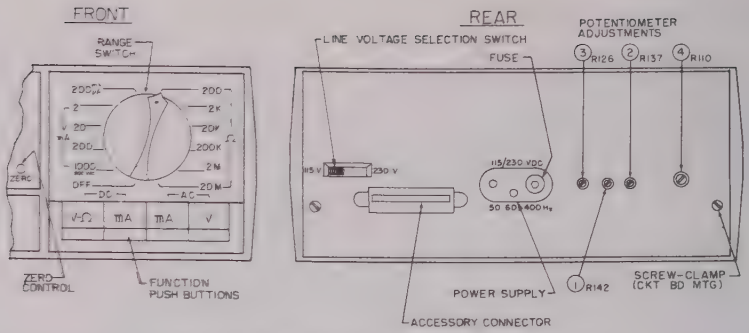

Figure 23. Calibration

If any of the performance checks fail, a recalibration may be required. The starting point of any recalibration is the setting of zero. This should be done on the 200 mV DC range with the input leads shorted. Adjust the front panel zero control for a reading of 00.0 with the polarity signs flickering alternately. Then proceed as follows:

	Range Switch Setting	Function Push Button Setting	Input	Adjustment
1	200mV	DC/V-Ω	+200mV	Adjust R142 for readout of +00.0 with overrange "R" flashing.
2	200mV	DC/V-Ω	-200mV	Adjust R137 for readout of -00.0 with overrange "R" flashing.
3	20K	V-Ω	20KΩ	Adjust R126 for readout of 0.00 with overrange "R" flashing.
4	20meg	V-Ω	20mΩ	Adjust R110 for readout of 0.00 with overrange "R" flashing.

SCHMATIC DIAGRAMS AND ASSEMBLY DRAWINGS

This section contains the Schematic Diagrams and Assembly Drawings for the Weston Model 1240 Digital Multimeter. Reference symbols will be found on either the schematic or wiring diagrams. Item numbers will be found on the Assembly Drawings.

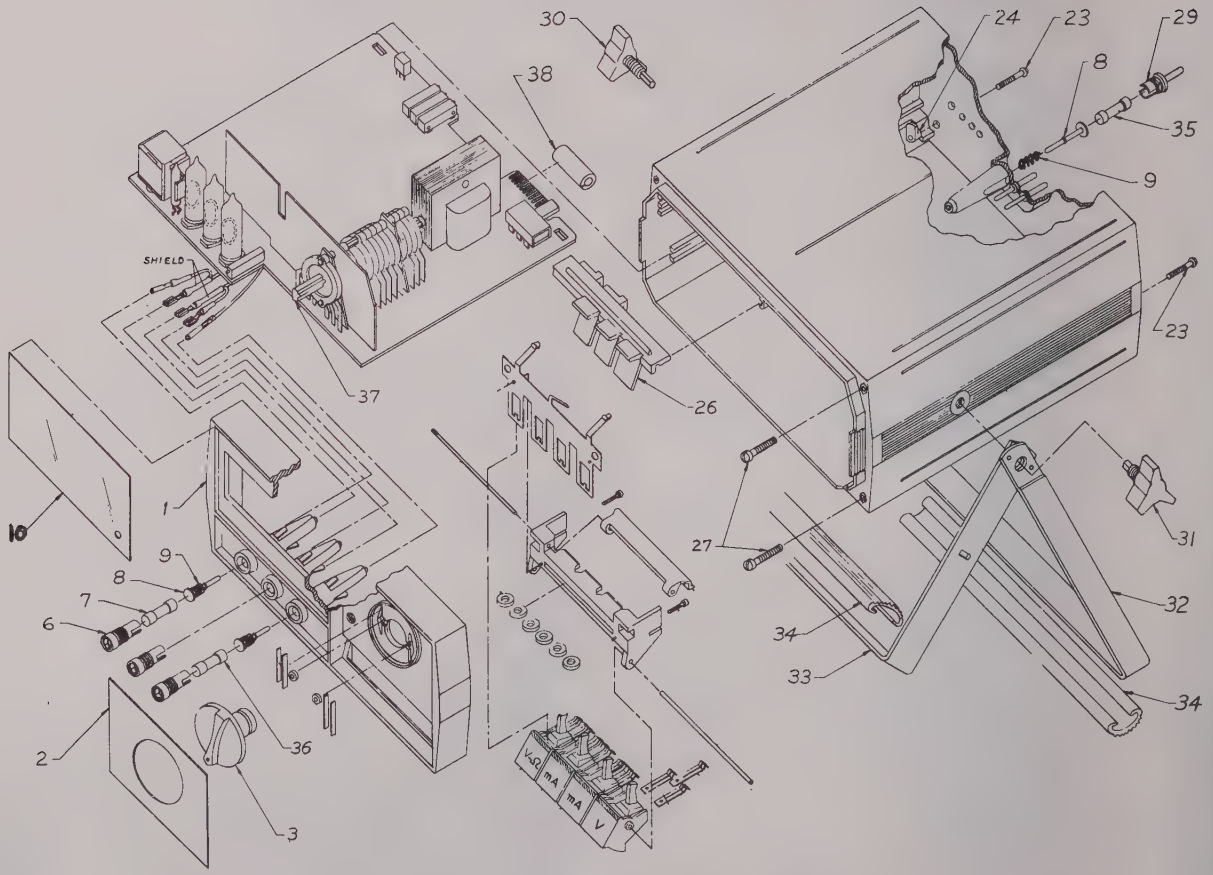

Figure 24. Method of Assembly

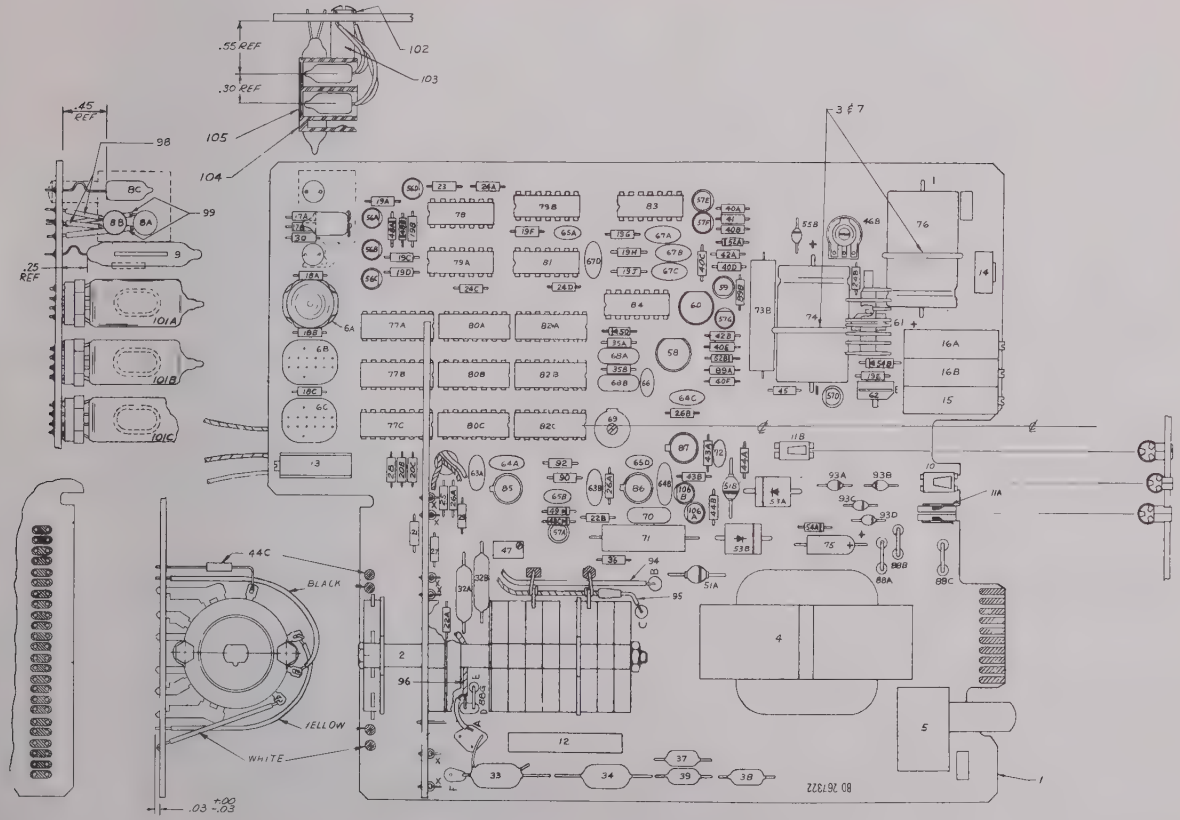

Figure 25. Board Assembly

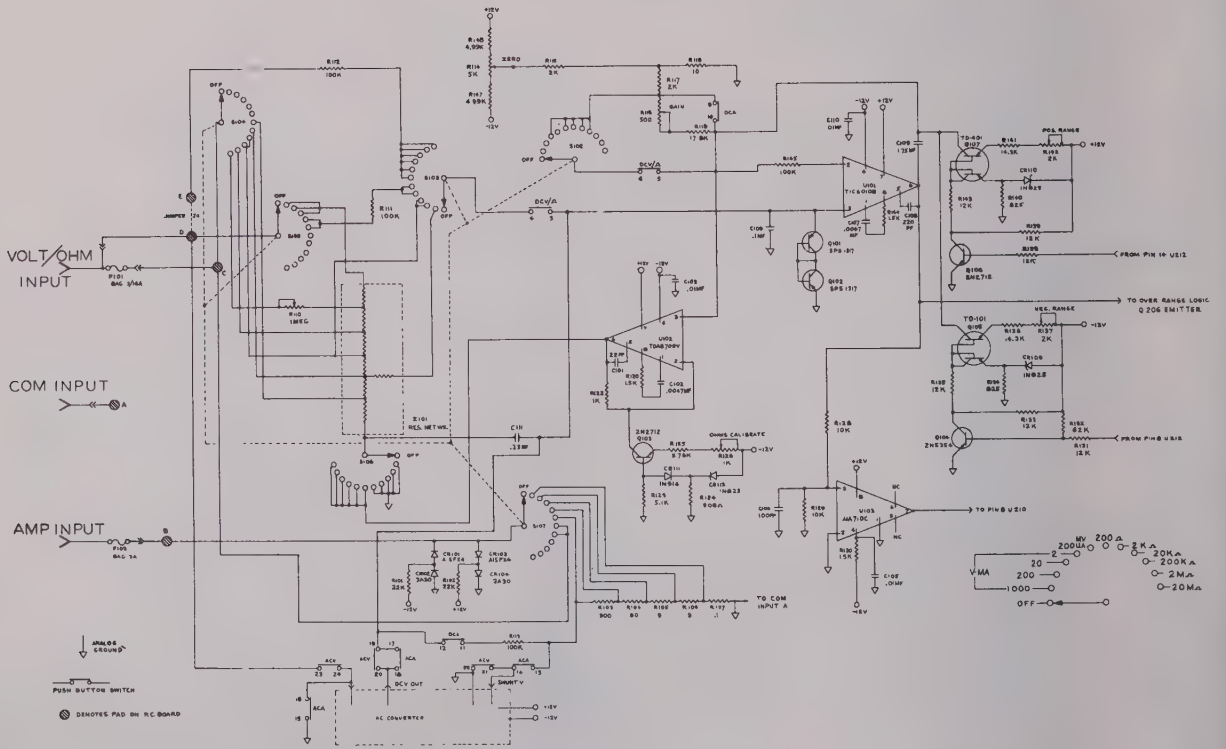

Figure 26. Schematic Analog Section

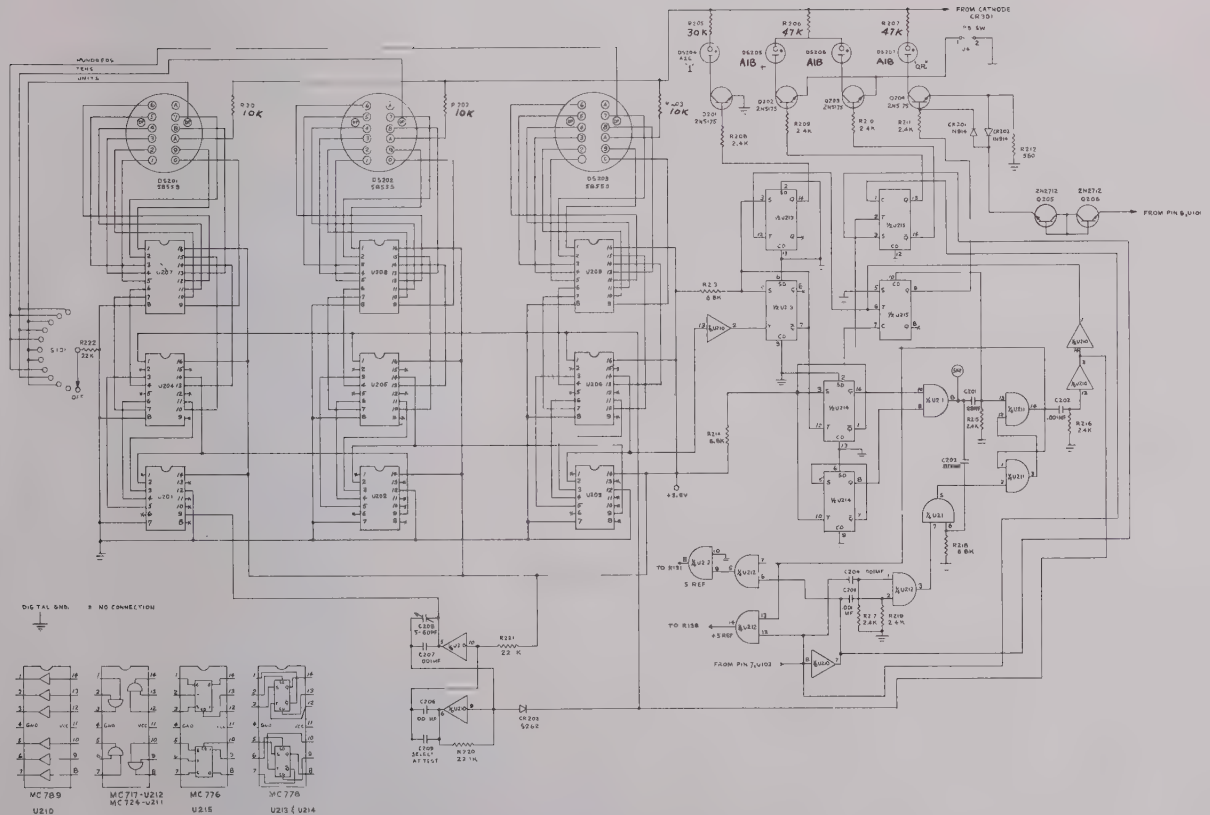

Figure 27. Schematic Logic Section

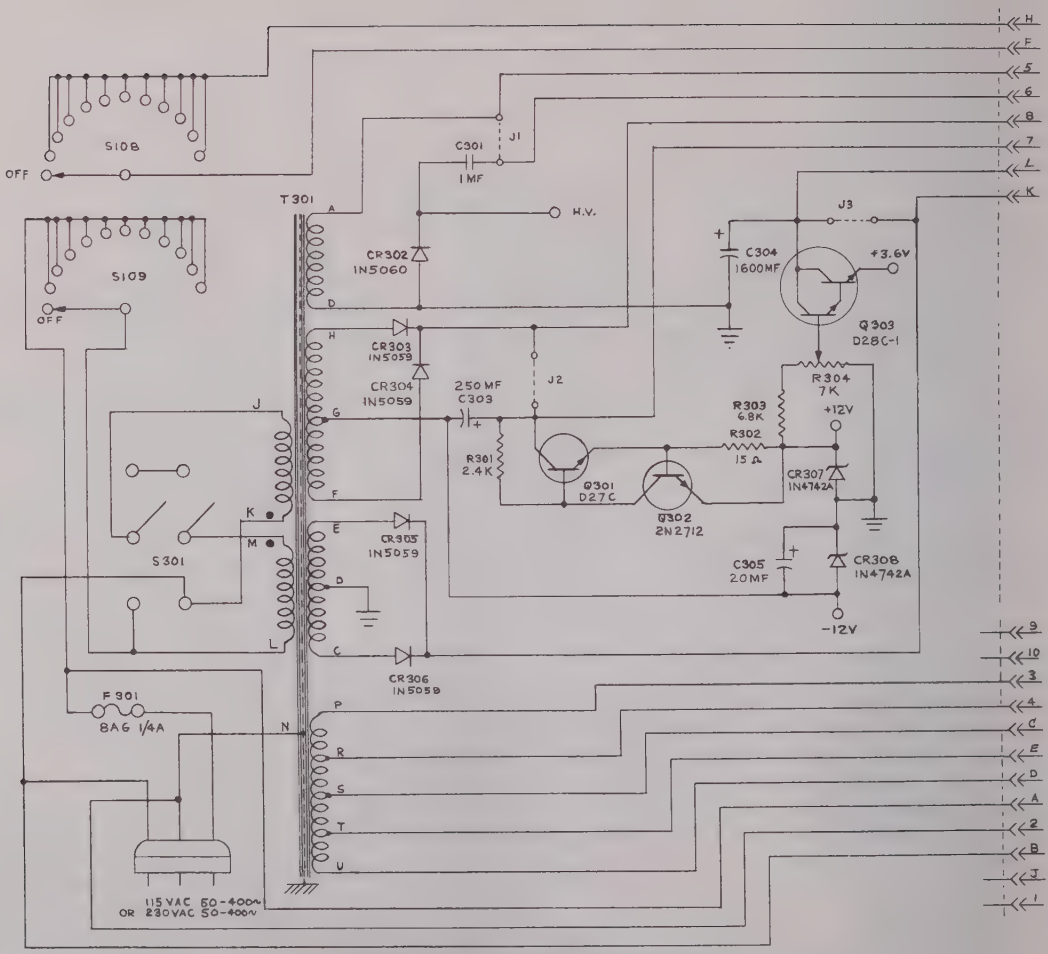

Figure 28. Schematic Power Supply

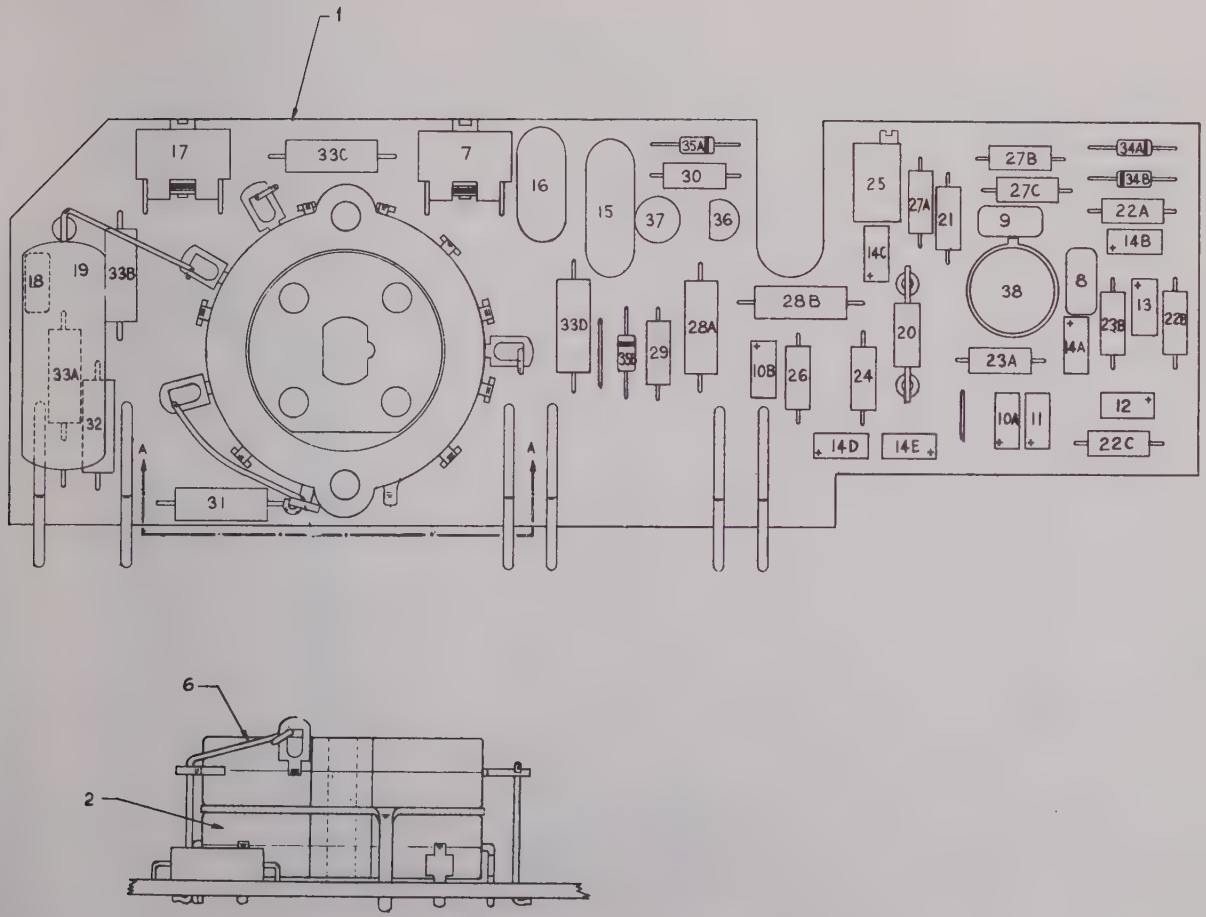

Figure 29. AC Board Assembly

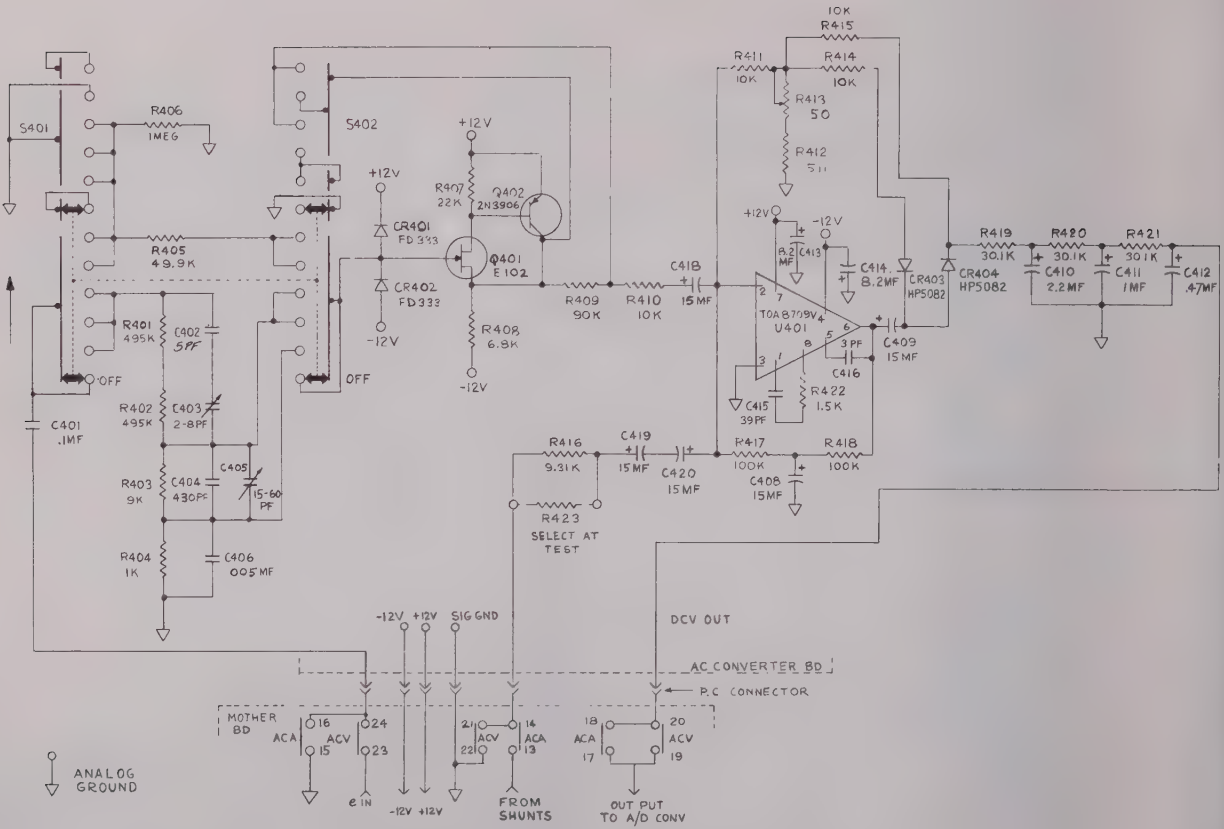

Figure 30. AC Converter Schematic

PARTS LIST

MODEL 1240

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Figure 25)	
C101	65B	CAPACITOR, 220pf	264091-001
C108	65D		
C201	65A		
C102	63A	CAPACITOR, .0047 μfd	269898-001
C107	63B		
C103	64A	CAPACITOR, .01 μfd	269899-001
C105	64C		
C110	64B		
C104	72	CAPACITOR, 100 pf	264089-001
C106	70	CAPACITOR, .22μf	272382-001
C109	71	CAPACITOR, 1.75μf	269897-001
C202	67C	CAPACITOR, .001μfd	263666-001
C203	67D		
C204	67B		
C205	67A		
C206	68A	CAPACITOR, 1000 pf	269935-001
C207	68B		
C208	69	CAPACITOR, 5-60pf	269936-001
C209	66	CAPACITOR, Factory Select	269548-901
C301	73B	CAPACITOR, 1μfd at 200V	269895-001
C303	74	CAPACITOR, 250 μfd at 64V	266349-001
C304	76	CAPACITOR, 1600 μfd at 10V	266607-001
C305	75	CAPACITOR, 10 μfd at 20V	265800-001

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
CR101	51B	DIODE, A15FX4	269969-001
CR103	51A		
CR102	53A	DIODE, 3A30	264724-001
CR104	53B		
CR109	52A	DIODE, 1N825	266309-001
CR110	52B		
CR111	48C	DIODE, 1N914	ND61025-001
CR201	48B		
CR202	48A		
CR112	49	DIODE, 1N823	ND60978-001
CR203	50	DIODE, S262	263643-001
CR302	55B	DIODE, 1N5060	266591-001
CR303	93D	DIODE, 1N5059	266611-001
CR304	93C		
CR305	93B		
CR306	93A		
CR307	54B	DIODE, 1N4742A	264601-001
CR308	54A		
Q101	106A	TRANSISTOR SPS1317	270075-001
Q102	106B		
Q103	57A	TRANSISTOR, 2N2712	ND39917-001
Q205	57E		
Q302	57D		
Q106	57G		
Q206	57F		

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
Q104	59	TRANSISTOR, 2N5354	268795-001
Q105	60	TRANSISTOR, TD101	266399-001
Q107	58	TRANSISTOR, TD401	269904-001
Q201	56C	TRANSISTOR, 2N5175	266585-001
Q202	56B		
Q203	56A		
Q204	56D		
Q301	62	TRANSISTOR, D27C	269902-001
Q303	61	TRANSISTOR ASSY	269564-001
R101	44A	RESISTOR, 22K	264674-001
R102	44B		
R222	44C		
R103	37	RESISTOR, 900Ω	269942-001
R104	38	RESISTOR, 90Ω	269941-001
R105	39	RESISTOR, 9Ω	269940-001
R106	34	RESISTOR, .9Ω	269939-001
R107	33	RESISTOR, .1Ω	269943-001
R110	14	POTENTIOMETER, 1.15 Meg.	269918-001
R112	32A	RESISTOR, 100K	269912-001
R111	32B		
R113	22A	RESISTOR, 100K	266631-001
R145	22B		
R114	13	POTENTIOMETER, 5KΩ	269919-001
R115	28	RESISTOR, 2K	270105-001
R147	20B	RESISTOR, 4.99K	269911-001
R148	20C		

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
R116	25	RESISTOR, 10Ω	269915-001
R117	21	RESISTOR, 2K	269926-001
R118	47	POTENTIOMETER, 500Ω	269917-001
R119	27	RESISTOR, 17.8K	270074-001
R120	26A	RESISTOR, 1.5K	264677-001
R130	26B		
R144	26C		
R122	29	RESISTOR, 1K	266628-001
R123	92	RESISTOR, 5.1K	ND37341-001
R124	90	RESISTOR, 909Ω	269916-001
R125	36	RESISTOR, 5.76K	269994-001
R126	15	POTENTIOMETER, 1K	264641-001
R128	43B	RESISTOR, 10K	269887-001
R129	43A		
R131	40A	RESISTOR, 12K	266613-001
R133	40B		
R135	40D		
R138	40C		
R139	40E		
R143	40F		
R132	41	RESISTOR, 62K	263651-001
R134	42A	RESISTOR, 825Ω	269888-001
R140	42B		
R136	89B	RESISTOR, 14.3 K	269927-001
R141	89A		

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
R137	16A	POTENTIOMETER, 2K	269901-001
R142	16B		
R304	46B	POTENTIOMETER, 7KΩ	256087-902
R201	18C	RESISTOR, 10K	264673-001
R202	18B		
R203	18A		
R206	17B	RESISTOR, 47K	264676-001
R207	17A		
R208	19D	RESISTOR, 2.4K	266615-001
R209	19C		
R210	19B		
R211	19A		
R215	19F		
R216	19J		
R217	19H		
R219	19G		
R301	19E		
R212	23	RESISTOR, 560Ω	269910-001
R213	24C	RESISTOR, 6.8K	269891-001
R214	24A		
R218	24D		
R303	24B		
R205	30	RESISTOR, 30K	269908-001
R220	35A	RESISTOR, 22.1K	269955-001
R221	35B		
R302	45	RESISTOR, 15Ω	269909-001

PARTS LIST

MODEL 1240

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
U101	86	MICROCIRCUIT	269960-001
U102	85	MICROCIRCUIT TOA8709V	268794-001
U103	87	MICROCIRCUIT UA710C	269903-001
U201	80C		
U202	80B	MICROCIRCUIT CUL9958	266596-001
U203	80A		
U204	82C		
U205	82B	MICROCIRCUIT CUL9959	266595-001
U206	82A		
U207	77C		
U208	77B	MICROCIRCUIT CUL9960	266397-001
U209	77A		
U211	81	MICROCIRCUIT MC724P	264608-001
U210	84	MICROCIRCUIT MC889P	269896-001
U212	83	MICROCIRCUIT MC717P	264609-001
U213	79A		
U214	79B	MICROCIRCUIT MC778	269921-001
U215	78	MICROCIRCUIT MC776	269920-001
DS1	101A		
DS2	101B	TUBE, READOUT	266601-001
DS3	101C		
S1	5	SWITCH, DPDT, SLIDE	269957-001
T301	4	TRANSFORMER	267362-901

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		BOARD ASSEMBLY (Cont.)	
D54	9	BULB, NEON	266537-001
D55	8B		
D56	8A	BULB, NEON	269877-001
D57	8C		
-	12	ATTENUATOR	269078-001
		AC CONVERTER (Figure 29)	
C401	19	CAPACITOR, 0.1 µf/630v	270014-001
C402	18	CAPACITOR, 5pf 5%	272359-001
C403	17	CAPACITOR, 2-8pf	270009-001
C404	16	CAPACITOR, 430 pf	270079-001
C405	7	CAPACITOR, 15-60 pf	270081-001
C406	15	CAPACITOR, 0.005µf ±5%	270011-001
C408	14A		
C409	14B		
C418	14C	CAPACITOR, 15µf	269951-001
C419	14D		
C420	14E		
C410	13	CAPACITOR, 2.2µf	269953-001
C411	12	CAPACITOR, 1µf	269954-001
C412	11	CAPACITOR, 0.47µf	269991-001
C413	10B		
C414	10A	CAPACITOR, 8.2µf	269952-001
C415	9	CAPACITOR, 39pf	269949-001
C416	8	CAPACITOR, 3pf	269947-001

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		AC CONVERTER (Cont.)	
CR401	35A		
CR402	35B	DIODE, FD333	269922-001
CR403	34A		
CR404	34B	DIODE, HP5082-2800	269959-001
Q401	37	FET, E102	269958-001
Q402	36	TRANSISTOR, 2N4126	269956-001
R401	33A	RESISTOR Pkg. 495K	269983-001
R402	33B	RESISTOR Pkg. 495K	269983-001
R403	33C	RESISTOR Pkg. 9K	269983-001
R404	33D	RESISTOR Pkg. 1K	269983-001
R405	32	RESISTOR, 49.9K	270028-001
R406	31	RESISTOR, 1 MEG Ω	268782-001
R407	30	RESISTOR, 22K	264674-001
R408	29	RESISTOR, 6.8K	269891-001
R409	28A	RESISTOR Pkg. 90K	269984-001
R410	28B	RESISTOR Pkg. 10K	269984-001
R411	27C		
R414	27B	RESISTOR, 10K	269887-001
R415	27A		
R412	26	RESISTOR, 511Ω	270004-001
R413	25	POTENTIOMETER, 50Ω	270003-001
R416	24	RESISTOR, 9.31K	270015-001
R417	23A		
R418	23B	RESISTOR, 100K	266592-001

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		AC CONVERTER (Cont.)	
R419 R420 R421	22C 22B 22A	RESISTOR, 30.1K	269931-001
R422	21	RESISTOR, 1.5K	264677-001
R423	20	RESISTOR, Factory Select	269555-901
S401	3	SWITCH, Range	269077-001
S402	2	SWITCH, Range	269443-001
U401	38	MICROCIRCUIT TOA 8709V	268794-901
-	1	CIRCUIT BOARD, AC Drilled	269060-001
		INDICATOR ASSEMBLY (Figure 24)	
-	1	FRONT, MOLDED	267327-901
-	2	DIAL, PRINTED	267356-901
-	3	KNOB, RANGE SELECTOR	267331-001
-	6	SOCKET, BANANA PLUG	267330-077
F101	7	FUSE 3/16 AMP 8AG (V/Ω INPUT)	269937-001
-	8	CONTACT, BANANA PLUG	269062-001
-	9	SPRING	270006-172
-	10	WINDOW, PRINTED	267328-901
-	23	SCREW (CKT BD MTG)	266623-045
-	24	CLAMP (CKT BD MTG)	265661-024
-	26	TUBE, CLAMP	269437-001
-	27	SCREW, PANEL MTG.	ND32910-024
-	29	PIN, A.C. FUSE	269066-001
-	30	KNOB, HANDLE, Small hex	269546-001
-	31	KNOB, HANDLE, Large hex	269547-001

PARTS LIST

MODEL 1240

REF. SYMBOL	ITEM NO.	DESCRIPTION	WESTON PART NO.
		INDICATOR ASSEMBLY (Cont.)	
-	32	HANDLE/STAND, Rear	267346-001
-	33	HANDLE/STAND, Front	267345-001
-	34	GRIP, HANDLE/STAND	267347-902
F301	35	FUSE 1/4 AMP 8AG (A.C. PLUG)	ND29787-001
F102	36	FUSE 3 AMP 8AG (AMP INPUT)	269938-001
-	38	GUARD, EDGE CONNECTOR	267351-001
-	-	CABLE, POWER	269985-001
-	-	LEAD, TEST SET	270066-001
-	-	ADAPTER, BLACK CLIP	269997-001
-	-	ADAPTER, RED CLIP	269996-001

WESTON EQUIPMENT WARRANTY

Weston warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Weston equipment, at an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that (a) Seller is promptly notified in writing by Buyer upon discovery of defects, (b) Upon receipt of written authorization from Seller the defective equipment is returned as directed, transportation charges prepaid by Buyer, and, (c) Seller's examination of such equipment discloses to his satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as tubes, lamps, etc.

This warranty is in lieu of all other warranties, expressed or implied, including the implied warranty of fitness for a particular purpose to the original purchaser or to any other person. Seller shall not be liable for consequential damages of any kind.

The aforementioned provisions do not extend the original warranty period of any article which has been either repaired or replaced by Seller.

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